Progress of negative air ions in health tourism environments applications

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Abstract

The acknowledge on air ions beneficial bioactivities, especially those negative charge, small size and oxygen composition rich atmospheres; may indicate local environmental quality, increase health tourism attractiveness, promote wellbeing and support therapies. Negative air ions (NAI) microclimates anomalies by natural mechanisms or controlled generations may indicate a natural therapeutic factor (NTF) to the health resort medicine, SPA and wellness tourism development.

To identify these kind occurrences and their potential bioactivities, this study employs literature review concerning "air ions" definitions, classifications, genesis, environments, anomalies, NAI/cm^3 measurements, bioactivity range and healthy applications. Followed by sites selection, with comparative features at preferably traditional wellness or health tourism destinations; where "in situ" NAI concentrations are measured for further physical comparisons and likely healing indications at each place maximum NAI value observed.

The case studies here are six Brazilian locations: 1. Itaipuland/PR (Cave SPA termal); 2a. Guarapari/ES (Areia Preta beach) y 2b. Guarapari/ES (Seacoast downtown); 3. Aguas de Lindoia/SP (Public balneary and emanatorium); 4. Foz do Iguaçu/PR (Cataratas Waterfalls Park); 5. Caldas de Cipó/BA (Urban public thermal pool); and 6. Piracicaba/SP (Riverside urban forest Park).

Mainly NAI generation characteristics and level concentrations evaluated, resemble to their world similar examples reviewed. The values ranging between 2100 to 156000 NAI/cm^3 implies all locations chosen as potential NTF at invigorating environment, clean fresh air atmosphere, satisfactory tourism air quality index, market biological effects to health resort programs and psychological benefits. Just cases destinations 1, 2, 3 and 4 endue ionic density (>15000 NAI/cm^3) possibly used for air ionotherapy treatments, including medical specialties: neurology, rheumatology, dermatology, pneumology and immunology.

Key words: negative air ions, air ionotherapy, SPA natural resourse, wellness tourism, health resort, geomedicine, climatotherapy, balneology, aerosol, microclimate

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Avances acerca de iones negativos del aire en aplicaciones para ambientes de turismo de salud

Resumen

El conocimiento acerca de la actividad biológica beneficiosas de los iones en el aire, especialmente de aquellos con cargas negativas, de tamaño pequeño y en atmósferas de composición rica en oxígeno; puede indicar la calidad local ambiental, incrementar el atractivo para el turismo de salud, promover el bienestar y orientar terapias. Los microclimas con anomalías de iones negativos en el aire (NAI) debido a mecanismos naturales o generación controlada pueden comportar un factor terapéutico natural (NTF) a tener en cuenta en Medicina Termal, Balnearios y el desarrollo del Turismo de Bienestar.

Para identificar estos fenómenos naturales y sus efectos bioactivos potenciales, este estudio emplea la revisión de la literatura con respecto a las definiciones de los aeroiones, clasificaciones, génesis, ambientes, anomalías, mediciones de los NAI/cm^3, cuantificación de los efectos bioactivos y posibles aplicaciones saludables. Seguido de la selección de sitios, con características compatibles con destinos de bienestar o turismo de salud, preferiblemente tradicionales; donde las concentraciones de NAI "in situ" se miden para realizar después comparaciones físicas y las probables indicaciones saludables de aquellos lugares donde se observa el valor máximo de NAI.

Los casos estudiados corresponden a seis ubicaciones de Brasil: 1. Itaipuland/PR (Cave SPA termal); 2a. Guarapari/ES (Playa Areia Preta) y 2b. Guarapari/ES (Centro urbano costero); 3. Aguas de Lindoia/SP (Balneario público y Emanatorio); 4. Foz do Iguaçu/PR (Parque das Cataratas); 5. Caldas de Cipó/BA (Piscina pública termal pública); y 6. Piracicaba/SP (Parque urbano de ribera).

Principalmente, las características de generación de NAI y las concentraciones evaluadas se asemejan a ejemplos similares mundiales compilados. Los valores obtenidos oscilan entre 2.100 a 156.000 NAI/cm^3, pudiendo indicar que todas las ubicaciones elegidas como potenciales NTF representan: entorno estimulante, atmósfera limpia de aire fresco, índice de calidad satisfactorio del aire en zonas turísticas, efectos biológicos evidentes para los programas de Medicina Termal y beneficios psicológicos. Solo los casos destinos 1, 2, 3 y 4 tienen una densidad iónica (> 15.000 NAI/cm^3) potencialmente utilizadas para tratamientos de aeroionoterapia, incluyendo afecciones médicas del campo de la neurología, reumatología, dermatología, neumología e inmunología.

Palabras clave: iones negativos del aire, aeroionterapia, terapias de SPA, turismo de salud, medicina termal, geomedicina, climatoterapia, balneología, aerosol, microclima

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INTRODUCTION

Actually, the World wellness industry annual accounts more than US$ 3.7 trillion, representing approximately 5% of the global economy output market. It involves sectors such as: health/wellness tourism, well-being lifestyle real state, complementary alternative medicine (CAM), SPA centers, public health (preventive, chronicity and social security), anti-aging, beauty, healthy mind-body, workplace welfare and thermal/mineral springs healing properties[1].

All these sectors have environmental factors as key components, in accordance with World Health Organization (WHO) International Classification of Functioning Disability and Health (ICF), and must be considered like external influences for each component on functioning and disability. Whether as a make up the physical, social and attitudinal environment in which people live, conducting their lifes, perform jobs, visit to seek leisure, wellness or health[2].

So, for the same ICF-model, environmental factors hold increasingly applications to the urban green and blue spaces health promotion concept. Among economic sectors mentioned above, special importance possess the physical environments and natural resources rely to the health resort medicine (balneology, medical hydrology and climatotherapy) core elements, were controlled exposure at short term local visitations improve and maintain functioning and minimise or prevent disabilities. These health-promoting atmospheres may be related to many others medicine practices, therapies interventions, holistic approaches, leisure pursuance and health or wellness tourism destinations development[2-3].

These sectors are commonly based on their local environments or resources, like natural therapeutic/healing/remedy factors (NTF) with potential bioactivities substantiated and represent tourism attractivities (landscape, climate, air, gas, water, salt, mud, sand). In this respect, NTF form the starting point and the very crux to SPA, health resorts, sanatoriums and wellness places[4-5-6-7].

Numerous researches show positive physiological actions to the health and well-being through nature experiences, involving the five human senses exposures (sight, smell, hearing, taste and touch) and also, by non-sensorial pathways, such as phytoncides, microbes and negative air ions (NAI) inhalation or absorption[8].

At urban atmospheres, NAI occurrence can play an important role in absorbing dust, air cleaning and breath problems reducing; thus, being able to represent a reliable air city quality index measure and provide theoretical foundation, technical guidance for planning and constructing a healthy-green urban area[9-10].

Some countries, like Georgia, studies about light aeroions concentrations are part of the bioclimatic characteristics in the tourism climate index, useful to the health resort tourism local potential and indicated suitable place to ionotherapy development[11]. Also called aeroanions, their sanative effects usually improve a tourism environment air quality index growth[12].

In the late 1800's it was confirmed that air electricity actually depended on the presence of electrically charged molecules found naturally in the air. Since charged airborne particles were discovered, their electrical properties are associated with atmospheric phenomena and biological effects. Their interactions influence ecosystems and global climate[13]. Near to the ground, abnormally high air ions concentrations may occur in some microclimates, where temporary exposure can affect the human health by favourable or unfavourable ways. In the early 1900s, their biological benefits and therapeutic potential have been known and researched, especially where the small and negative air ions concentrations are naturally high, related to the "ionic" SPAs or "radionics resorts" environments in Europe and Russia[14-15-16-17-18].

The natural air ionization is an electrical power important physical factor of the air to the weather, atmosphere and biometeorological observations[19]. The environment NAI contents are considered as NTF to the main types of bioclimates from natural SPA heritage regulatory subject, with rigorous evaluations[20]. Mainly, regarding to the climatotherapy practice potential in the health resort programme or to the forest bath medicine concept[21-22-23-24].

Therefore, this study aims to evaluate NAI content from traditional Brazilian destinations environments with microclimates NAI anomalies threshold values, potential bioactivity indication regarding a local NTF useful to the health, wellness and tourism applications.

METHODOLOGY

Initial knowledge about negative air ions (NAI) natural microclimates anomalies locations in the world, with variated generation mechanisms, their characteristics, concentrations and applications are literature reviewed through the keywords: "air ions", "negative air ions", "negative air ions" AND "environment", "negative air ions" AND "generation", "negative air ions" AND "concentration", "ions/cm3". In the digital databases: 1. scholar.google.com; 2. periodicos.capes.gov.br (articles, journals, english language); 3. PubMed; 4. sciencedirect.com.

Among these results, selected publications adopt *inclusion criteria: contain the related theme, describes air ions origins, classifications or generation mechanisms, encompass natural* environments, tourism destinations, content NAI/cm3 anomalies concentrations and healing bioactivities potentials.

Next, its health benefits or therapeutic indications, exposure features and minimum bioativities NAI values, are evaluated by other literature review, with keywords: "air ions" AND "therapy", "negative air ions" AND "exposure", "negative air ions" AND "effects", "air ions" trial, "air ions" review, "ionotherapy". In the digital databases: 1. scholar.google.com; 2. periodicos.capes.gov.br (articles, journals, english language); 3. PubMed; 4. sciencedirect.com; 5. cochranelibrary.com.

Among these second group results, selected publications adopt inclusion criteria: contain the related theme, describes psychophysiological benefits, experimental effective studies, therapy clinical trials or treatments meta-analysis systematic review, health diversified indications, exposure features, evaluating the physical environments and encompass NAI/cm^3 minimum bioactivity concentrations.

Based on obtained informations, to progress these knownledge allowed to the tourism environments, some Brazilian destinations are selected for prospective and comparative study. The target locations take into account criteria: recognized tourism visitation, similar to natural example evaluated before, potential NAI anomaly occurrence and distinctive generation mechanism. Thus, the NAI concentrations in ions/cm3 measurements are carried out "in situ" at the selected places, with the handled apparatus "Air IonCounter AIC - AlphaLab Inc., USA". This instrument is a true ion density meter, based on a Gerdien Tube (Gerdien Condenser) design, and it contains a fan that pulls air through the meter at a calibrated rate.

Maximum measured NAI values and those selected from the literature reviews comparisons appraisal to the measurements erros notions, cause-effect similarities between target sites, potential bioactivities in therapeutic indications meta-analysis references, subsidies to future researches, clinical trials and wellness/health tourism promotion related to a NTF.

RESULTS

Among hundreds international scientific publications founded to addressing “air ions” (206 results PUBMED) definitions, classifications, genesis, environments, anomalies, measurements, applications and benefits; the following information are compiled.

Air ions are electrical charged particles, being then mobile and temporary gaseous medium constituents; counting atmospheric conductivity indicators. It’s originated when enough energy acts on a molecule (carbon dioxide, oxygen, water or nitrogen), expelling an own electron and leaving a positively charged ion. The displaced electron binds to a nearby molecule, which then becomes a negatively charged ion[25]. Further these two polarities (+or-), also can be physical differentiated by their atomic dimensions and related shapes and electric mobilities, as: small (<1.6 nm diameter, fast molecular agglomerates), large (>30 nm diameter, slow aerosol particles) or intermediate[13].

Natural low atmosphere, near to the Earth’s surface, has average frequency production air ions (both positive and negative) about 10 ions/cm^3/sec[26]. At where, small ions lifetime duration range 50 to 250 seconds, and indoor places near 30 seconds; while large ions can persist for several days[27]. During their existence, undergo a series of ion-molecule reactions and continuously identity changing[28].

The chemical composition of small air ions depends on their source, age and trace gas presence.

The formation of small ions is limited mainly by the ionization rate of air molecules. The air ionization is a complex phenomenon, several stages constituted, depending on the present molecules and the generation atmosphere physical components. Primary ions (singly charged positive ions and free electrons) form via ionization of air molecules, and they become small ions in less than a second. In initial stage, primary ions are produced, for example the oxygen ones[21].

Among NAI, the main naturally occurring chemical species are O^-, O_2^-, O_3^-, CO_3^-, CO_4^-, HCO_3^-, NO_2^- and NO_3^-[29]. The Superoxide (O_2^-) is the main negatively charged species of NAI and is more stable than other ions[30].

Ionizing radiation is an energy type released by atoms, traveling in the electromagnetic waves form (γ-rays, X-rays) or corpuscular radiation particles (neutrons, α, β)[31]. Interaction between the energetic radioactive particles and molecules in the air occurs by directly collision or due electrical influence, such as with gamma radiation. The greatest nuclear ionization of the nuclear radiations is caused by alpha-particles and a large numbers of energetic collisions with gas molecules in air cause many ions to be formed by the air molecule fragmentation[32].

In the lower atmosphere, ionizing energy particles main sources, are: air radioactivity from radon/thoron gases (ionization rate=4.6 ion pairs/cm^3/s), radioactive elements decay contained in the surface minerals (ionization rate=3.5 ion pairs/cm^3/s, when each atom eject an alpha particle with produced energy capable to centimeters displacing) and cosmic radiations (high energy protons from supernovae, ionization rate=1.9 ion pairs/cm^3/s)[33].

Beta particles released from radioactive elements, emit electrons that bind to oxygen molecules (O_2), resulting NAI (O_2^-) formation. Ionizing radiation usually generates more small negative ions in the air[29].

As secondary natural physical ionizing agents (or generation mechanisms), include: shearing of water droplets (waterfall, rainfall, steam, mist - Lenard Effect), hot spring nascent, UV rays, sunlight, photosynthesis (forest), photoelectric emission, lighting excitation, electricity (corona discharge), electrostatic force, aurora borealis, cave, mountain, rapid flow of great air volumes over a land mass (Fohn, Sharav, Santa Anna), wind (sand and snow friction)[29-34].

The main natural atmospheric influence conditions on their energy generations are: humidity, temperature, pressure and wind[16]. In a free atmosphere the ions contents and types, depend on: ionizing agent intensity (energy), geological, climatic and geographical local conditions, others secondary or anthropogenic physical ionizing agents (air pollution degree)[19].

Some human activities capable to generate air ions: urban garden (blue/green space), wet sauna, water park, ionization place, artificial ionizers (corona discharges, thermionic electron emission from hot metal electrodes or photo-electrodes, radiation from radioisotopes, UV irradiation, high-pressure water injection, anion

incentive, tourmaline and other natural ores), dense urbanization atmosphere, pollution, suspended particles, power lines, industrial and vehicular emissions[13-29].

In the urban and polluted environments, NAI concentrations may be reduced to less than 100 ions/cm^3, due to the loss by anthropogenic aerosols attachment connections[27-35]. The atmosphere NAI enrichment can significantly oxidize volatile molecules, deodorising air, decrease or eliminate dust particles, fog, smoke, vehicle exhaust and reduce bacteria or pollen extract; by their aggregate and sediment on grounded surfaces potential[32-34].

The small ions exist all time in the atmosphere and their concentrations vary significantly between different environments; being that ground level, outdoor and non-polluted air range 200 to 2500 ions/cm^3 with the ratio between positive and negative air ions in 5:4. Natural microclimates sites containing above 5000 ions/cm^3 are not common and usually related to the physical anomalies occurrences[28].

World Health Organization (WHO) standards, account fresh air atmosphere one that has oxygen NAI concentration above 1000 ions/cm^3. Chinese standards criterion of air quality and the corresponding NAI concentration is divided into seven levels, where level S with super best pure and fresh air degree related to >10000 NAI/cm^3 and level 1 with best pure and fresh air degree related to >2000 NAI/cm^3[35-36]. To the Russian standards, ambience with small NAI content 1500 ions/cm^3 is hygienically satisfactory[37] and according COMECON standards, their concentrations range 3000-5000 ions/cm^3 equivalent to optimal ionization level[38].

Atmosphere ions are essential for cleaning the air, by charging all suspended matters (particles, bacteria, viruses, and allergens), making their aggregate and sediment[27]. Many studies provide evidence for negatively charge ionized gases in inhaled air are necessary to vital functions activation, body defence and improving our health[18]. NAI are termed "air vitamins" as they have an important biological influence on various microorganisms and positive effects on humans[30].

The beneficial bioactive capacity to human health through natural air ions rely on exposures (ways, periods) and ionic characteristics (concentrations ranges, electrical charges, chemical compositions, types). Thus, preferentially bioactivity conditioned to the air ions properties: small size, negative charge and composed by oxygen, superoxide, hydrogen peroxide, hydroxyl radicals and other reactive oxygen species (ROS)[18-26-37-39]. Although most publications report adverse actions to the positive air ions[19-40], for others, there are no conclusive evidence[38-41]. With rare exceptions, negative polarity is being predominantly employed in ionotherapy[42].

High natural NAI levels has been detected in specific wellness or health tourism destinations environments: SPA health resorts, urban gardens, forest baths, seaside's, waterfalls, hot springs, steam baths, salt mines, radioactivity and radon/thoron microclimates anomalies (beach sand, cave, spring); where are reported their favourable effects on human beings, comfort and fatigue feelings[43]. For instance, these are certainly cases related to the natural small oxygen NAI species and

their density contents (ions/cm^3) are exemplified in some occurrences reviewed Table 1.

Table 1 – Healthy NAI environments, generation mechanisms features and concentrations

Environment	Feature	NAI/cm^3	Reference
Health Resorts	SPA countryside	1180-4000	(21; 23; 26)
Băile Herculane/ROM	Hot spring-SPA area	2500	(53)
Motoyu Nasu/JAP	Hot spring	1920	(52)
Krimml /AUT	Waterfall mountain (57 m)	13012	(50)
Gartl/AUT	Waterfall mountain (66 m)	10000	(47)
Shinki Sauna	Wet vapour "indoor"	20000	(51)
Ojo Guareña/SPA	Radon/CH_4 cave	45000	(59)
Cisarska/CZE	Radon cave (1m)	38800	(24)
Monazite mineral	Artificial Radon/Thoron spring	50000	(58)
Gastunite mineral	Artificial Radon/Thoron spring	7000	(57)
Wieliczka/POL	Salt mine	4700	(55)
Cacica/ROM	Salt mine	1300	(21)
Maiji/CHI	Urban forest	2514	(9)
Chuanbei-Shanghai/CHI	Urban park forest river	2050	(30)
Beidaihe/CHI	Forest sport park	1000-2000	(36)

As biometeorological relevant assessment to the traditional health resorts activities, natural air ions concentrations are measured. When clean atmosphere usually get above 2000 ions/cm^3 and with negative charge prevalence, may indicate benefits to sedation, leads to real healing biological actions and recovery for certain disorders: neurosis, bronchial asthma and high blood pressure[21-26-37].

Their cognition will increase balneal-medical value to the resort programs, SPA centers facilities, attractiveness for wellness and health tourism destinations[19-23]. In this sense, can be related knowledge: ionotherapy, health resort medicine, SPA therapy, balneology, medical hydrology, climatotherapy, nature therapy and geomedicine.

Forests are the main continuous natural source of NAI, because leaf tips have a photoelectric effect during photosynthesis, which are able to promote electrolysis

and produce large NAI quantities. Additional air ionization occurs through aromatic substances released by vegetation, such as phytoncide. Woodlands, forest city parks, green spaces or urban gardens can be considered as major stable NAI origins in urban areas; where improve environmental quality, increase healthful gaseous components, aerosols absorption capabilities to the air purification, induce recreation, wellbeing and positive effects on humans. In this way, they should be part of any greening land use planning and sustainable urban construction systems[9-30].

Factors in the forest environment that may provide beneficial physiological effects include: plant aromas, temperature, humidity, light intensity, wind, NAI and oxygen concentrations. Can be exemplified here, through the lower diastolic baseline levels (DPB) observations due NAI abundance, with significant reduction in human (elderly) hypertension after experiencing a short-term forest bathing trip. Investigations into physiological and psychological conditions showed that performance efficiency and mental state were improved exposure to 1838 NAI/cm^3 in Zhejiang/CHI forest park[44].

With average concentration 2514 NAI/cm^3 at green/blue spaces (Maiji/CHI urban vegetated areas) is possible suggests an influence on people's moods, memory and behaviors, recovering their physiological responses after exercise, which can make people feel thoroughly relaxed by alleviating pressure and eliminating bad feelings[9]. In this sense, can be related knowledge: nature therapy, forest bath medicine and climatotherapy.

Special focuses attention on the obvious but overlooked perpetual source of reactive oxygen species (ROS) for living beings, such as NAI exposure received from the air ocean**,** constantly possible natural delicate influx of ROS into the organism, maintaining their vital steady-state concentration at the proper level[(37)]. Small oxygen NAI occur in invigorating natural environments, such as: waterfalls, pine forests, mountains or seashores with marine aerosols at range 4000 ions/cm^3 [(42)]. Analysis of the air conductivity data has shown that, when aerosol concentrations are large, the negative ions are physically smaller than when the aerosol concentrations are low. In the clean air, there is little competing surface area for the removal of condensable vapour, and the ions have a relatively long average lifetime. The Norfolk coast/UK has NAI average concentrations 1500 ions/cm^3 [(45)]. In this sense, can be related knowledge: nature therapy, thalassotherapy and aerosol therapy.

Traditionally, numerous beneficial health effects have been attributed to waterfalls in various regions of the world and represents fundamental natural environment to the health resort medicine concept. Their recognized ionic density is locally generated by waterfalls through the process of falling water splashing onto solid (rocks) and aqueous surfaces, inducing charge separation. Aerosolized water hitting the ground, the droplets created in the waterfall form dipoles with a negatively single charged surface predominantly maximal diameter about 2 nm. The charged nano aerosol generation within microseconds after primary ions ionization, due to hydration and cluster ions formation processes. These also called "Lenard ions",

endue superoxide compositions and hold markedly superior lifetimes through its water shearing process essentially considered a natural NAI source[29-46-47-48].

The physical characterization of waterfall-generated ions can basement part of a randomized controlled clinical study, which focused on the influence of these waterfall generated ions and aerosols on pediatric allergic asthma, stress-immunology and burnout prevention, lung and heart physiology, mucociliary clearance[49]. Some these features production depends on: the fall height, water flowing quantity per time, location nature, shape and surrounding topography. Related physical pathways, which can produce waterfall ions: auto ionization of water molecules, fluctuating charge rearrangement, surface protrusions, evaporation of droplets formed in collisions, Coulomb explosion, computed velocities of primary waterfall droplets required to break up into two new ones, their velocities and dimensions. Here, NAI may occur at concentrations above 10000 ions/cm^3 [28-47-50].

Among natural environments with high NAI levels, near to the hot springs atmospheres are sometimes mentioned[16-51]. When their no related to radioactive substances or radon emanations, the possible causes for production these ionic densities: gases and vapour emanations, strongly ionized air in the cavities and capillaries of the earth-crust carrying ions may come out a the consequence of the lowering of the barometric pressure and give up the ions, extremely penetrating radiation which has ionizing action may come from the earth or heavenly bodies, sunlight may have ionizing and electrifying action, corpuscles with high velocities and therefore having ionizing power may come from heavenly bodies, frictional forces on water, breaking micro-particles or bubbles from water surface, evaporation process, atmosphere physical changes and water emitted electromagnetic radiation in the far infrared region[19-21-34-52-53-54].

The salt mines also usually microclimates contents high NAI density, precincts walls with smooth surfaces and saline aerosols atmosphere where ionic enrichment occur by crystals breaking generation of electric load, which arrive then in inside air through evaporation, because of the sharp edges and corners of salt crystals[21]. In Wieliczka/POL salt mine case, the overstated level of air ionization is due to the high air purity in the healing chambers, where low level of dust particles make practically impossible the small air ions transform into heavy ions[55]. In this sense, can be related knowledge: speleotherapy, halotherapy and aerosol therapy.

Natural radioactivity has particular importance, in this context, because it is the atmosphere major ionization source and capable to small oxygen air ions originating in the initial decay stage[21-32]. Thus, radioactive anomalies microclimates can be founded in the high natural background radiation areas (HNBRA) due presence of radionuclides elements in mineral, soil, water, gas or emanations from rare sites (spring, cave, beach, mine, fault). It is interesting to observe these occurrences which apply the radon SPA therapy. The World most studied HNBRA refers with monazite sand beaches in Guarapari/BRA, Rizhao/CHI and Kerala/IND[56]; at where

little information is mentioned about environmental air ions measures or their biological activity in these places.

The same scarcity occurred when searching about NAI relationship with radon springs environments and radon therapy applications. Interesting searches produce artificial radon/thoron hot spring by soaking radioactive minerals to decay products originate radon/thoron gas and oxygen NAI associated with water used in the radon bath therapy; indicated to lifestyle-related diseases caused by activated oxygen, osteoarthritis and bronchial asthma[57]. NAI measurements at 15 cm source distant show 50000 ions/cm^3 to the monazite mineral source and 7000 ions/cm^3 to the gastunite mineral source[58].

To illustrate other HNBRA kind with NTF potential, observe the Ojo Guareña/SPA radon cave where revealed an extraordinary degree of air ionization (concentration average up to 45000 ions/cm^3). The high density of ions in this cave atmosphere persists throughout the year because radon continuously levels above 500 Bq/m^3 and the absence of CH_4 in this subterranean system[59]. Other radon cave observed is Cisarska/CZE, where child patients suffering from bronchial asthma are treated using speleotherapy practice. Their high NAI concentrations (>38800 ions/cm^3) occur due to: radionuclides contained in limestone, very strong correlation between small ions concentrations with radon volume activity, constant cold temperature, high relative air humidity, calcium and magnesium ions presence in aerosol, modest air flow, low dust content, absence of allergens and bacteria. At this microclimate type, is taken as suitable for therapeutic usage when NAI concentration up to 1000 ions/cm^3 [(24)]. In this sense, can be related knowledge: speleotherapy, aerosol therapy and radon therapy.

Following the second literature review including therapy, medicine, healing, wellness and others biological terms; also numerous scientific publications are founded (144 results PUBMED). Due to the NAI generating sources, two groups can be differentiated: natural environments and artificial mechanisms. The natural NAI places selected are similar ionized environments to those previously described Table 1, with included potential healing indications, exposure features and minimum bioactivity NAI concentrations Table 2. And to the artificially NAI generation procedures, group where is evident the great majority researches related; the preferred examples in Table 3 are selected due: encompass NAI/cm^3 minimum bioactivity concentrations with compatible dosage related natural ionic environments, diversified healing indications, similar to natural generation mechanisms and positive efficacy described.

Comparing to the natural ionization, through different types of generators apparatus, ions concentrations of both polarities (in limited spaces) that attain high values, arriving at a few millions ions/cm^3, may be obtained under the ionized artificially controlled exposure atmosphere. Thus, natural ionized environments can be reproduced some factors, with more stable properties and sufficient NAI large density to therapeutic treatments; just by artificial ionization provided[19-21-30].

Table 2 - Natural healing indications, exposure features and mínimum bioactivity concentrations

Indication	Exposure	NAI/cm^3	Reference
Pediatric asthma, speleotherapy	Radon cave	38800	(24)
Sedative, climatotherapy, healing chamber	Salt mine bioclimate	1300-4700	(21; 55)
Asthma pediatric, lung function, mucosal immunity, chronic stress	Waterfall 1h/1week	15000	(47; 49; 50)
Bioenergetic bioregulation	Waterfall near	10000	(46)
Healing natural environment	Waterfall	10000	(36)
Prevent disease	Forest mountain	5000-10000	(36)
Biological actions real healing, health resort medicine	Rural clean air	1000-10000	(37)
Marked biological effects	Natural conditions	1500-4000	(14)
Sedative effect on the body	Hot spring resort	2500	(53)
Sanitaria	Coast	2000-5000	(36)
Invigorating natural environment	Seashore	4000	(42)
Improve immunity, basic health requirements	Garden urban park	1000-2000	(36)
Elderly hypertension	Shinrin-yoku forest bath	1838	(44)
Psychological balance, eliminate tiredness, treats diseases, improve health	Guangzhou sanitarium	1057	(22)

Table 3 - Artificial healing indications, exposure features and minimum bioactivity NAI concentrations

Indication	Exposure	NAI/cm^3	Reference
Killing bacteria, accelerated growth in plants and insects, physiological behavioral changes in animals and humans	Artificial ionizer	50000	(41)
Optimal bioactivity hypertension disease	Ionization level hours	25000-40000	(38)
Circulatory system	Ionization regular level	10000	(38)
Arterial pressure, blood rheology normalization, tissue oxygenation, stress conditions, adaptation to adverse factors	Small NAI O_2	10000	(18; 26)
Effect SOD activity, improving accelerated aerobic metabolism	Water shearing ionizer	3000	(46)
Increase body temperature, sweat production, pulse rate, amplify sauna effects	Wet sauna	20000	(51)
Lifestyle related diseases – Radon therapy	Monazite artificial thoron spring – 15 cm	50000	(58)

Although some authors highlight the unique attributes of nature, local coexistence with others NTF, the comparative larger areas of NAI comprehensiveness, greater natural distance extent, superior small NAI lifetime and continuous NAI

natural generation[25-19-29-60]. Also, different ionizers models, generations sources and apparatus powers (therapeutically devices until air cleaners); may induce errors in literature meta-analysis to the clinical evidence[16].

Further ionizer generators, artificial sources including in Table 3 are: radon spring source radioactive minerals and wet sauna source water steam.

Well-documented effects of experimentally produced ions (of usually one polarity) include the killing of bacteria (>50000 ions/cm^3), accelerated growth in plants and insects, and physiological and behavioural changes in animals and man[41].

Despite some meta-analysis found "no persuasive evidence" for NAI beneficial medical/biological effects[60-61], many cases of successful treatment are observed in different countries, described by extensive meta-analysis reviews: Charry (1984), Kellogg (1984), Krueger (1985), Yates et al. (1987), Kinne (1997), Kondrashova et al. (2000), Laza (2000), Wallner et al. 2015) and others 77 publications (PubMed search with used Medical Subject Heading - MeSH terms for air ionization) selected in this study about positive results through animal tests or human trials (some examples at Tables 1, 2 and 3).

Since the beginning of the 20th century there has been a scientific debate about the potential effects of air ions on biological tissues, wellbeing and health. Effects on the cardiovascular and respiratory system as well as on mental health have been described. Over the past 80 years, extensive literature (518 studies) has been published pertaining to the NAI potential biological effects, which examines their beneficial exposures on psychological measures of mood, emotional state and respiratory function[61]. Since the 1980's, reviews related NAI healthy bioactivities efficacy referred dozen studies publications: 57 Charry (1984), 80 Krueger (1985) and 76 Yates et al. (1987).

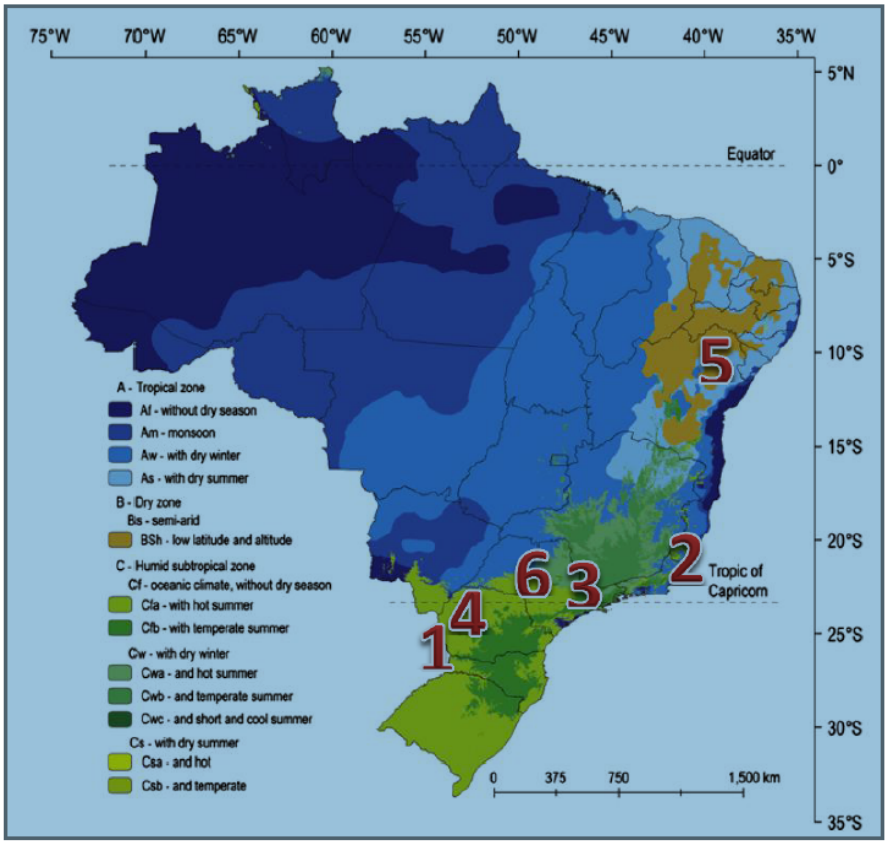
Literature review quoted main welfare and therapeutic air ions applications related: (i) conditioned emotional response, (ii) comfort, learning and physical or cognitive performance, (iii) serotonin regulatory system, (iv) pain and analgesic, (v) physiological responses changes, (vi) pulmonary function and respiratory system, (vii) cardiovascular parameters, (viii) neurohormonal balance and (ix) burns and antimicrobial[8-19-26-39-40-41].

The evident NAI bioactivities observed in several studies could be explained by electric charge ability to amplify some physicochemical particles properties involved in the physiological mechanisms16. This electricity power becomes bioavailable through the inhaled ions direct pulmonary alveoli sensory nerve endings interactions and many blood components being conductivity charges sensitive, affecting their organic and biochemical characteristics responsible to the metabolism increase. Air ions exposure through the skin, although lesser importance, also results in biochemical reactions and particles trans-membrane transport account to the nerve impulses propagation[19].

Based on obtained information, to progress these knowledge allowed to the wellness natural and health (SPA) tourism environments, six Brazilian destinations

are selected for prospective and comparative study. The target locations take into account criteria: recognized tourism visitation, a similar example evaluated here, natural NAI anomaly site and distinctive generation mechanism microclimates. The NAI/cm^3 concentrations measurements "in situ" carried at the selected places, in different environmental features capable to NAI density (ions/cm^3) enough to BAC with potential NTF occurrences, for future studies basement Figure 1 and Table 4. Following natural setting descriptions:

Figure 1 – Brazilian "ionic" destinations in climate KOPPEN classification criteria map[62]



1. Itaipuland/PR – Cave SPA thermal, steam room with salt wrapping, a wet sauna similar place created by temazcal geothermal (40 °C) sulphate-bicarbonate-chloride sodium water to the bath and inhalation SPA procedures in a speleotherapy atmosphere, being inserted in a hot water park and health resort complex.

2. 2a. Guarapari/ES - Areia Preta beach, acknowledged HNBRA, due monazite sand containing up to 0.3% uranium and 7% thorium, radon-thoron emanation (635 Bq/m^3), tropical coast climate with thalassotherapy tourism potential, where visitors traditionally apply sand bath to the health. 2b. Guarapari/ES - Seacoast downtown, near to estuarine summer tropical environment, foth an urban hotel.
3. Aguas de Lindoia/SP – Public balneary, hot radon springs set with strong water and gases (radon, thoron and oxygen) outflow, emanatorium room microclimate exposures (12000 Bq/m^3), historically watering place by low mineral content and oxygen balneotherapy, together a mountain forest climatotherapy.
4. Foz do Iguaçu/PR – Cataratas Waterfalls Park, create a large aerosol microclimate with high spray density, easily accessible exposure, surrounded by a tropical rainforest reserve and representing an international tourism destination.
5. Caldas de Cipó/BA – Urban public thermal pool and artificial downtown cascade, supplied by a hot spring isothermal water (36 ^{o}C), flowing sorely, with calcium chloride composition and manganese radiosotopes dissolved, city holding richest thermalism history to the Brazilian northern region, with a semi-arid particular bioclimate.
6. Piracicaba/SP – Riverside urban forest Park, near to the rip tide cascade, green-blue space microclimate on the hills top belvedere, often local community leisure and wellness tourism visitation.

Table 4 - Tourism destinations, environment features, maximum measured NAI concentrations and ground height collected

#	Place	Nature	NAI/cm^3	Height
1	Itaipuland SPA-Sauna	Temazcal vapour	156000	1.5 m
2a	Areia Preta /Guarapari	Monazite beach	63400	0.1 m
2b	Downtown /Guarapari	Urban coast	2500	1.5 m
3	Águas de Lindoia	Radon spring	55000	0.4 m
4	Cataratas do Iguaçu	Waterfalls mist	18610	1.5 m/ 50 mD
5	Caldas de Cipó	Hot spring	3300	0.2 m
6	Piracicaba River	Urban forest	2100	1.5 m

DISCUSSIONS-CONCLUSIONS

Through the information compiled in this study it is possible to predict environments microclimates higher density in small NAI, especially those oxygen composed, with potential bioactivities to the wellbeing and human health benefits.

Their physical knowledge about concentration value range can indicate anomalies, possible healing applications and local bioclimate control like NTF required by health resort program, SPA tourism or natural ionotherapy.

By this methodology, six target destinations are selected, where NAI/cm^3 concentrations higher than atmospheric background are 100% confirmed and endue levels capable to physiological or psychological effects in a healthy environment to live or visitation attractiveness (>2000 NAI/cm^3).

The salty vapour room with geothermal pool and cascade (1.Itaipuland/PR Cave SPA Thermal) show biggest NAI measurement, consistent with similar caves, salt mines, hot springs and wet saunas environments evaluated. This ionic density may suggests ionotherapy treatments including here and also, for selected cases 2, 3 or 4 (>15000 NAI/cm^3).

Concomitant historic tradition and wellness feelings at all these places may indicate physically environmental NAI anomalies like a local NTF to the health, wellness and tourism. Prompt hope to the natural/historic/cultural heritage preservation and public health inducing: life quality, welfare (mood, performance, relax, detox), medicine indications (metabolism, respiratory and circulatory systems), elderly care and chronic diseases treatments.

Progress on NAI knowledge related to their environmental health, wellness and sustainable tourism applications are expected for healthy or traditional destinations; especially those microclimates endowment features: salty, mist, vapour, minerals-waters-gases radioactivity, water (waterfall, radon spring, sea, minerals, urban blue space), forest (photosynthesis, organic aerosol, urban green space), cave, mine, park, garden, beach, fountain, cascade or artificial controlled rooms.

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