

## GLOBAL EARTH MAGNETIC FIELD AND RECREATIONAL ENVIRONMENT: ISSUES TO BE ADDRESSED

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### Abstract

*Have you ever noticed that there are places where a person can feel relaxed, full of energy and revitalized? These places may be recreational locations (tourist resorts, wellness, and spa-centers) and tourist attractions (churches, monasteries, geo-parks, etc.). On the other hand, the therapeutic benefits of electromagnetic field radiation on human's body have already been medically proven. The objective of the paper is to introduce some new insights and raise a discussion if the existence of such magnetic fields may be a reason why people feel more relaxed and healthier when visiting or staying at such recreational environment. Thus, the authors argue the possible influence of the Earth's magnetic fields on the well-being of those who visit, sightsee or stay at tourist and leisure environment. Particular attention is raised within the optional utilization of the extra-low frequency as the Schumann resonance in recreational areas that are used for tourism and relaxing purposes.*

Key Words: *global earth magnetic field, Schumann resonance, recreation, wellness, tourism industry, human health*

JEL classification: *Q26, I12, L83*

### Introduction

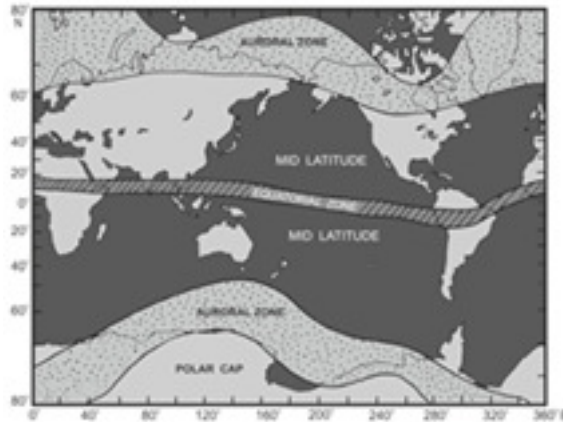
Besides the gravity, the magnetism is one of the fundamental properties of the Earth and it is native and fundamental to our planet's existence. While the discovery of the gravity was somehow dramatic as described by the story of the Newton and its apple, the discovery of magnetism was not as dramatic. It was believed that the Chinese were the most likely the first to discover the magnetic compass, as early as 2500 years BC. Yet, the existing written historical accounts about magnetism and its usefulness starts from the year 1000 BC, in China again.

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Around the 12<sup>th</sup> century AD, the knowledge of magnetism and its specifying property was transmitted from China to Europe, most likely through the east-west trade links. The historical voyages made by Christopher Columbus, Vasco de Gama, and Ferdinand Magellan, could not be even imagined without the magnetic compass. Christopher Columbus sailed across the Atlantic Ocean in 1492 searching for a 'short-cut' to the Indies and following the magnetic compass, reached the coastline today known as the Caribbean islands. For the first time, someone noticed that magnetism is not just a pure direction pathfinder, but also strongly depends on the latitude and longitude at different locations on the Earth's surface.

Figure 1: *Earth's division based on the changes of the magnetic field*



Source: *Basavaiah, (2011)*

In 1600, William Gilbert was probably the first, who realized that the source of the Earth's magnetic field comes from within the Earth rather than outside. He found that magnetism is the result of some kind of permanent magnet within the Earth itself. Later, Carl Friedrich Gauss, with the usage of spherical harmonic decomposition of the magnetic field, found that the source of the surface Earth magnetic field phenomenon is internal indeed. However, the most significant breakthrough was done by Henry Gellibrand who excluded the permanent magnet as a source in 1634. This was followed by Edmond Halley who observed for the first time that some magnetic features were drifting westward, and concluded that the Earth's interior might be liquid. Thus, the history of Earth's magnetic field research might be subdivided into three main periods:

- Firstly, a *proto-scientific stage* (up to the 16<sup>th</sup> century), characterized with a gradual increase for the issue and development of casual hypotheses mostly based on observation and intuition;
- Secondly, an *early-modern stage* (16<sup>th</sup> to early 19<sup>th</sup> century), whereas the directional data (magnetic declination, inclination, and intensity) were increasingly measured, compiled, and mapped; and
- Thirdly, a *modern stage* (from the 1830s), with measurement of the full magnetic vector (direction and intensity) in dedicated scientific surveys, observatories, and lastly using space satellites.

Today, the most widely accepted theory is the Larmor's hypotheses from 1919 according to which the Earth's magnetic field is continually being created and destroyed by fluid motions in the Earth's interior. Since the electricity and magnetism are commonly generated by dynamos, it was named as the *geodynamo*. In fact, permanent magnetism also does occur, but only in the crustal magnetic field of the Earth, and its contribution to the global Earth' magnetic field is very weak and static compared to the main internally generated magnetic field (Cingoski & Yamashita, 1997). Generally, this crustal or lithospheric field is about 400 times smaller than the geodynamo magnetic contribution and ranges from 0 to  $\pm 1000$  [nT].

Recently, interest is paid to the *biomagnetism* as a special scientific field dealing with the influence of the global Earth's magnetic field on the humans and their entire life, in the first line on the physiological and nervous system. Hence, a large number of academicians argued that this influence could and should not be neglected. Some other, more specific studies focus on the so-called Schumann resonance magnetic field frequencies that exhibit some interesting and peculiar properties not only to the human's environment but also to the human's behavior and human's wellbeing. Moreover, these low frequencies of about  $f_b = 7.83$  [Hz], and the multiplications, such as  $2 \cdot f_b$ ,  $3 \cdot f_b$ , or  $4 \cdot f_b$ , etc., have a specific influence on the human's brain.

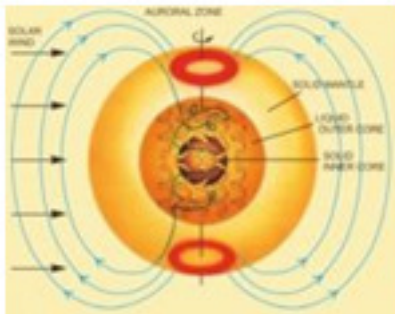
This paper posts some interesting issues that may be addressed in association with the Schumann resonance and its influence on humans. It has been observed that there are some locations where people feel more relaxed, the body is rejuvenated, the brain and heart electric activity is empowered, thus leading to improved human wellbeing. The objective of the paper is to introduce some new insight and raise a discussion if the existence of such magnetic fields as the Schumann resonance frequency

may be a reason why people feel more relaxed and healthier when visiting some recreational locations (like tourist resorts, wellness, spa and recreation centers) and tourist attractions (like churches, monasteries, geo-parks, etc.).

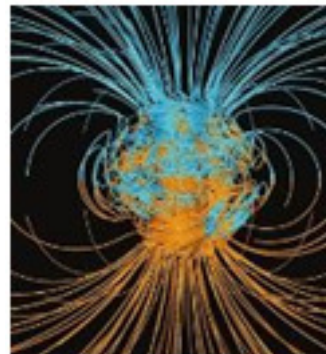
### Global Earth magnetic field: Origin

The Earth is a very complex and multi-structured rocky type planet. Figure 2 shows the cross-section structure of the Earth in its interior and the structure of its surrounding atmosphere. Due to a geodynamo mechanism in the outer liquid and metallic Earth's core, the main part of the Earth's magnetic field is known as the main field or core field (Figure 2). Such flow is driven by buoyancy forces and influenced by the Earth's rotation and generates large electric currents that induce a magnetic field, compensating for the natural decay of the field over the space and time.

Figure 2: *Models of Earth's magnetic field, a) simplified dynamo model, b) Glatzmaier-Robert MHD geodynamo model*



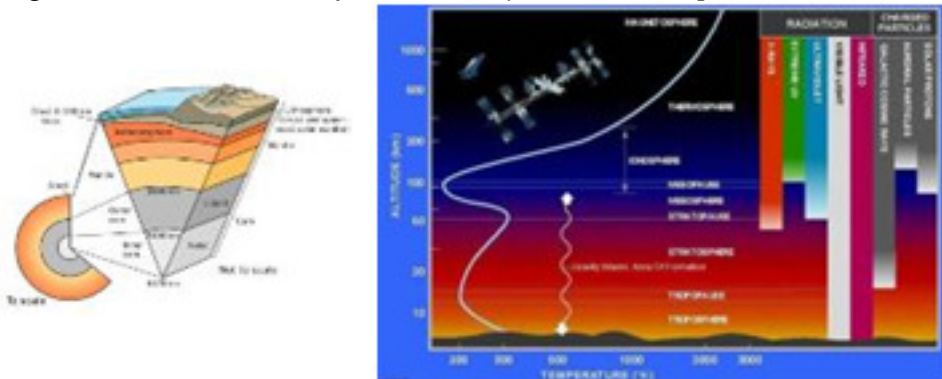
Source: *Basavaiah, (2011)*



Source: *Buffett, (2008)*

There are also external components of the magnetic field that could be measured at the Earth's surface (Noguchi & Cingoski, 2017). They increase going downwards from the higher Earth's atmosphere towards Earth's surface and do not originate from the Earth's dynamo effect, but from the Earth's ionosphere (Figure 3). Since solar magnetic activity changes in short periods (hours or days), these magnetic storms and substorms have much shorter timescale provoking strong impact on the temperature of the Earth's atmosphere, electric discharge and generation of thunderstorms and weather and climate changes. Furthermore, the impact is noted on the telecommunications, electricity grids and finally on human behavior and overall wellbeing.

Figure 3: *Cross-sections of Earth's body and its atmosphere*

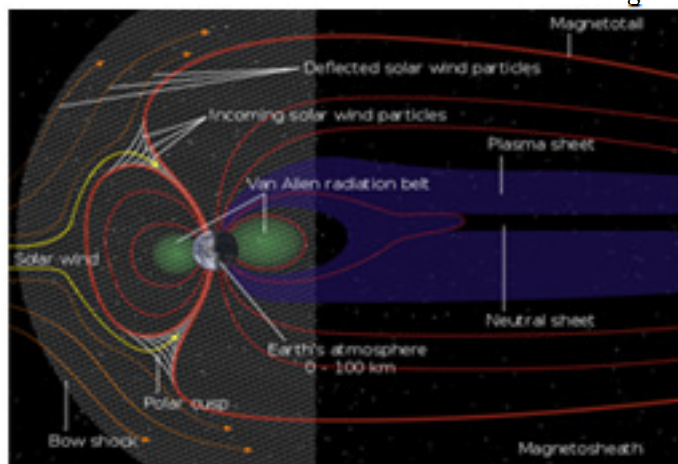


Source: [www.usgs.gov](http://www.usgs.gov)

Source: [www.theozonhole.com](http://www.theozonhole.com)

The Earth's atmosphere could be divided into several distinguished zones: *troposphere* (<10 km), *stratosphere* (<50 km), *mesosphere* (<100 km), and *thermosphere*, or the other edge of Earth's atmosphere (<400 km) (Figure 3). Part of the thermosphere coincides with the existence of two other outer layers of the Earth's atmosphere, the *ionosphere* (between 60 km and 200 km), and the *magnetosphere* (above 200 km up to 500 km), which mutually interfere due to the solar winds and magnetization. The effects of the solar wind differ in day and night side and vary on a range of timescales from minutes to hours and days.

Figure 4: *Relations between the solar wind and Earth's magnetosphere*



Source: [www.wikiwand.com/en/Magnetosphere\\_particle\\_motion](http://www.wikiwand.com/en/Magnetosphere_particle_motion)

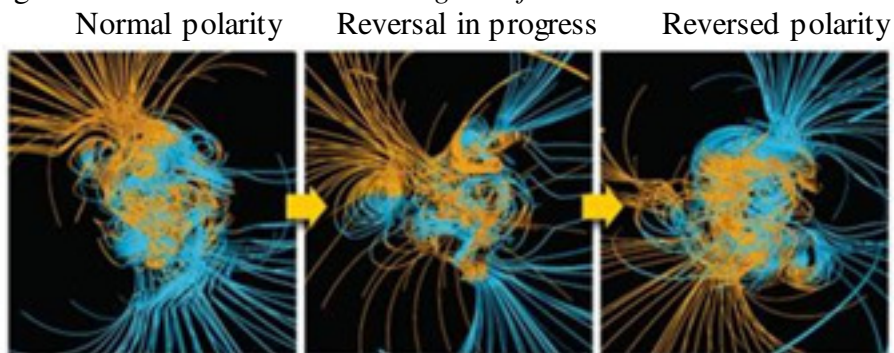
The layered structure of the Earth's atmosphere is crucial for the development and protection of life on Earth. While upper ionosphere and

magnetosphere protect the surface from intensive solar radiation, high velocity and high energy magnetic particles from the Sun, the much lower positioned ozone layer protects the Earth's life from extremely dangerous and hazardous UV radiation (Figure 4). Hence, with no magnetic field, life on Earth could not evolve and even exist. Yet, some parts of the plasma and radiation may penetrate the magnetic field barrier, leading to magnetic disturbances affecting the flora, fauna and humans.

### Variations of the Earth's magnetic field: Overview

Evidence from the study of rock magnetism shows that the Earth's magnetic field is certainly not static, but varies dramatically over long periods of time. Variations of the magnetic field could be not only by the intensity but also due to changes in some field properties, such as declination and inclination. In general, these variations could be divided as long-term and/or short-term field variations. The long-term variations are among the most interesting with the theory of its reversal, as the most intriguing. By analyzing the magnetization of the sediments and rock, it was determined that the Earth throughout its 4 billion years geological history, had undergone many complete magnetic reversals when the north and south magnetic poles exchange their locations on the Earth (Figure 5). Scientists believe that almost every 800.000 years the magnetic field reversal occurs.

Figure 5: *Reversals the Earth's magnetic field*



Source: <http://www.astronomy.com/magazine/>

However, since humans have a significantly shorter life span than any long-term events on Earth, including a long-term variation of Earth's magnetic field, an accent is put on the short-term variations. Herein, the main role plays the magnetic observatories being around 180 scattered all

around the world (Figure 6). They carry out continuous and accurate monitoring of the strength and direction of the Earth's magnetic field over many years, revealing how the field is changing on a wide range of timescales from seconds to centuries. This is highly important for understanding processes both, inside and outside the Earth.

Figure 6: *Locations of the magnetic observatories around the world*



Source: *Gubbins & Herrero-Bervera (2007)*

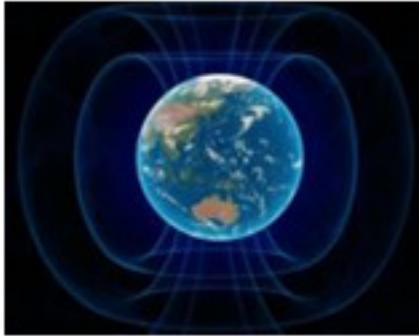
### **Biomagnetism**

Im et al., (2017) note that 'Biomagnetism is an interdisciplinary field of research that aims to understand, modulate, image, or repair human organs and tissues with internal or external magnetic fields' (p. 183). Recently, biomagnetism became popular, particularly as a diagnostic tool and a therapeutical procedure for many diseases, like neuronal or cardiac diseases, trauma injuries, pain, and heart miss functions and problems.

Almost two millennia ago, Chinese, Egyptians and Ancient Greeks used magnets therapeutically to relieve pain and discomfort. Much later, the German physician Franz Anton Mesmer defined new approach whereas the health was observed as a free flow of the process of life spreading through thousands of channels in the body, thus the body illness was caused by obstacles to this flow. This approach closely matches the Oriental systems description of illness as obstructed way of the flow of natural human energy called '*Qi*' or '*Chi*' or '*Prana*', through specific points on the human's body called '*chakras*' and '*meridians*'. By mere

analogy, the electromagnetic pattern of the Earth and the human body are rather identical (Figure 7).

Figure 7: *Analogy of Earth and human body magnetic fields*



Source: [www.wisegeek.com](http://www.wisegeek.com)

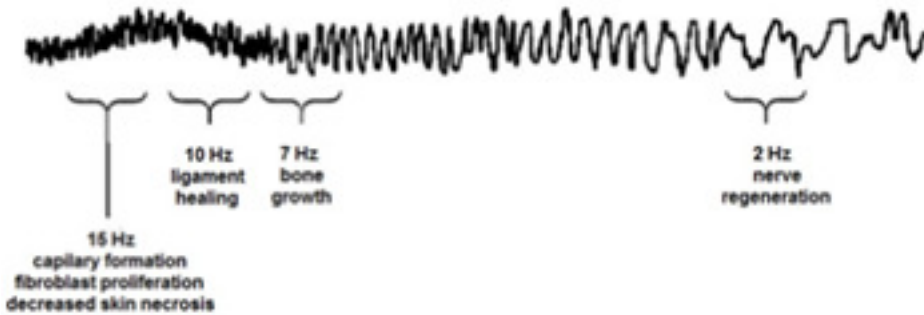


Source: [www.humanfrequencies.com](http://www.humanfrequencies.com)

While the major source for Earth's magnetic field is the electric currents deep in the molten outer core of the Earth, the source of electromagnetic fields in the human body could be traced in the rhythmic heart activities. The heart is by far the largest electric generator in the body. It continuously pumps and creates a magnetic field around itself which goes way beyond the skin. It creates various signals, like electric, sound, pressure, heat, light, magnetic and electromagnetic. Since the blood is an excellent electricity conductor, the circulatory system pulses with electricity each time the heart beats. This resulted with the invention of the first *electrocardiogram* (EKG), a device that records the electric activity of the heart (Human frequency blog (a)) in 1903. Two decades later, in 1924 the first *electroencephalogram* (EEG) was invented for measuring magnetic impulses from the human brain. This proved that the human body is heavily influenced not only by the external but also by the internal magnetic field generated within the body, called biofield.

The frequencies of biofields, particularly the so-called extreme low frequencies (ELF) provoked large attention in the late 20<sup>th</sup> and beginning of the 21<sup>st</sup> century. The frequencies of the pulsations range from 0.3-30 [Hz], but those from 7-8 [Hz] are found to have positive therapeutical effects on humans. Figure 8 presents that frequencies between 2 and 15 [Hz], whereas can be clearly seen that they end up at the range between 7 and 8 [Hz] pointing to an optimal best frequency.

Figure 8: *Low-frequency magnetic fields influence on the human body*



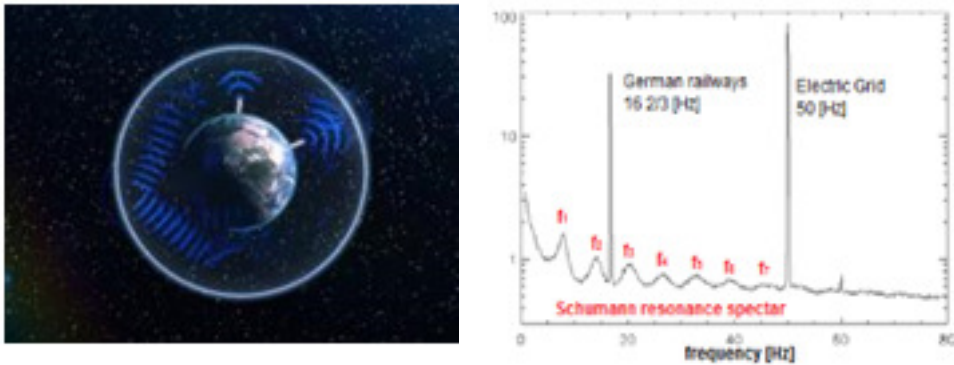
Source: *Human frequency blog (b) – According to Dr. John Zimmerman*

### **The Schumann resonance: Basics and influence**

Although initially proposed by Nikola Tesla in his patent from 1995 (Tesla, 1905), in 1952, Winfried Otto Schumann published his first paper about electromagnetic waves in the waveguide which is formed by the Earth's surface and the ionosphere (Schlegel & Füllekrug, 2007). Some of the waves – if they have just the right wavelength – combine, increasing in strength and creates a repeating "*atmospheric heartbeat*" known as the *Schumann resonance*. The fundamental Schumann resonance is at approximately 7.83 [Hz], which is an extremely low frequency at which the wavelength equals the circumference of the Earth, and higher harmonics occur at 14.1, 20.3, 26.4, and 32.4 [Hz], etc., respectively, as shown in Figure 9.

There are two major sources for the existence of the Schumann resonance waves. First, being lightning strikes that occur higher in the Earth's atmosphere, and the second, being an interaction between the solar wind and the magnetosphere. Due to their extremely long wavelength, these waves can diffract around large obstacles and are not blocked by mountain ranges or the horizon. That means that they can practically travel around the curve of the whole Earth, thus they can be actually measured and '*felt*' globally.

Figure 9: *Schumann resonance in the cavity between the Earth's surface and ionosphere (left), and Schumann's originally measured values for the first several frequencies of the resonance spectrum (right)*



Source: *Schlegel & Füllekrug, 2007*

Today, the influence of the Schumann resonance is vastly explored among the academicians. It is used as a tool for monitoring the global warming (Sekiguchi et al., 2006), the electric environment, and assists in determining the types of atoms and molecules in the Earth's atmosphere. Many studies argue the influence on the brain activities since the dominant frequency of the human brain of 10.5 [Hz] is very similar to the frequency of the Earth's core. Hence, a relationship occurs due to the resonant interaction with the neurons and the possible alteration of the melatonin–serotonin ratio in the human brain.

In this line, Babayev and Allahverdiyeva (2005) found that the influence on the human brain activity could be additionally enhanced in cases of geomagnetic storms that occur rather often in the Earth's atmosphere. According to Persinger and Saroka (2015), there is a remarkable congruence between the essential dynamic physical properties of the human cerebrum, and the electromagnetic signals in accordance with the Schumann resonance. Thus, they concluded that the consistency and congruence of the fundamental, harmonics, magnetic field intensities, electric field potentials, and phase shifts between the Schumann resonance and quantitative human cerebral cortical activity indicate the potential for information interaction. In other words, the human brain actively '*communicates*' with these basic electromagnetic waves existing within earth-ionosphere spherical waveguides.

Thus, during the long evolution phase, the human brain adjusted its normal activity to the most intrinsic Earth-based frequencies (*the*

*Schumann resonance and the Earth's core frequencies*), and actively interacts with them. In case of their obstruction or limitations, problems might occur with the normal human's brain activity leading to neurological disorders and deceases, such as disruption of melatonin synthesis, decrease in self-confidence and working ability, especially during the autumn and spring periods, depression and especially, manic-depressive illness, enhanced anxiety and sleep disturbances (Ward & Henshaw, 2016), Alzheimer's, Parkinson's, or Huntington's deceases (Gubbins & Herrero-Bervera, 2007), and even increased number of suicides (Ward & Henshaw, 2016; Brahic, 2008).

Besides on brain, the geomagnetic field is related to the normal human heart activities, heart rate, and blood pressure. The impacts could be either indirectly through the brain and nervous system disturbances that influence the normal heart operation, or directly on the heart and its parameters, such as systolic and diastolic blood pressure, mean arterial pressure, etc.

According to Mitsutake et al., (2005), the overall influence of the Schumann resonance frequency is very positive. They found that during days with increased Schumann resonance conditions, the heart rate, blood pressure, and overall heart conditions were improved and more favorable compared to the days with normal or suppressed Schumann resonance conditions, suggesting that Schumann resonance frequencies could have a positive effect on the heart bitrates and mean arterial pressure, regardless of age and gender.

Similar findings are noted in other related research studies (Ward & Henshaw, 2016; HeartMath Institute, 2019). During quieter magnetic periods Schumann resonance power appears to play an important role in synchronizing people's slow wave heart rhythms, thus calming the patients overall. On the other side, while the Schumann resonance frequencies act positively on the human heart and its rhythm, geomagnetic storms have a rather opposite and negative effect on the human heart (Ward & Henshaw, 2016). For example, the arterial blood pressure was found to increase significantly with the increase of the geomagnetic activity level. The systolic and diastolic blood pressure was found to increase significantly during the period from the day before till the second day after the geomagnetic storm occurs, thus have prolonged action. Also, increased geomagnetic activities have a negative effect on

the heart ischemic, most likely leading to potential ischemic heart disease and heart failure in the worst cases.

### **The Schumann resonance: Tourism and recreational aspects**

The variety of positive effects of the low-frequency magnetic fields (Schumann resonance) on the entire living, with a particular focus on human health and wellbeing, has been previously emphasized. This section briefly discusses the possibility to identify and promote locations where people visit to seek leisure, wellness or health (Morita et al., 2006) and feel more relaxed, with a rejuvenated body and empowered brain and heart activity, which lead to general improvement of their wellbeing.

The recreational environment may include numerous places that besides '*basic tourist product*' in terms of a tourist attraction, wellness service, geo-sightseeing, etc., may offer ultimate satisfaction in an ambient with positive and harmonious energy vibrations. Such tourist and recreational areas that are affected by the low-frequency electromagnetic fields, stream with high positive signals on human behavior and health conditions of tourists, visitors, and excursionists. Additionally, they may indicate local environmental quality, increase health tourism attractiveness and promote wellbeing and support therapies. Thus, tourism along with the wellness industry often relies on to the health-promoting atmospheres which may be related to many other medical practices, therapies interventions, holistic approaches, leisure pursuance, and health, leading to wellness tourism destinations development (Gutenbrunner et al., 2010; Morita et al., 2006).

The worldwide wellness industry accounts more than US\$ 3.7 trillion, representing approximately 5% of the global economy, and involves numerous sectors, like: health and wellness tourism, well-being lifestyle real state, complementary alternative medicine, spa centers, anti-aging, beauty, healthy mind-body, as well as the thermal and mineral springs healing properties (GWI, 2016). On the other hand, recreational environments are often based on their local resources in terms of factors with potential bioactivities, like natural therapeutic, healing and remedy elements that represent tourism attractions (landscape, climate, air, gas, water, salt, mud, sand, etc.) In this respect, such factors form an initial point for additional development of spa resorts, health resorts, sanatoriums, wellness places and similar recreational environment (ESPA, 2006; Illing, 2014; Munteanu et al., 2013; Rocha et al., 2014).

The presence of the Schumann resonance at such locations provoke positive physiological actions to the health and wellbeing through nature experiences, in the line of additional involving of the five human senses exposures (sight, smell, hearing, taste, and touch) (Lazzerini et al., 2018). Hence, as of early 1900s, many recreational environments detected their biological benefits and therapeutic potential (Krueger & Sobel, 1979; Kinne, 1997; Radovanovic & Dzhambasevic, 1987; Yates et al., 1987) and applied health resort programs and concepts (Enache et al., 2005; Linning, 2007; Roubal et al., 2017; Teodoru & Bunescu, 2009).

Traditionally, numerous beneficial health effects have been attributed to the power of biomagnetism in various regions of the world and today, biomagnetic therapy is one of the most promising therapeutic healing techniques. Yet, although the medicine widely applies techniques to monitor magnetic fields, such as ECG, EEG, and MRI, magnetic therapy is still behind (Null, 1998). Slowly, the awareness of the natural healing option rose, so it is often a case that recreational facilities offer to sleep in magnetic beds and souvenir shops sell small magnetic objects for energy, preventive purposes, and healing. Some destinations even base their wellness tourism development strategy on the therapeutic benefits of nature, like the unique magnet concentration in the sand of the Black Sea resort Ureki (Erkomaishvili et al., 2014). Other, use magnetism for tourism promotional purposes, like the Magnetic Island (an island in the Coral Sea in the Cleveland Bay in Queensland, Australia), being named upon the 'magnetic' effect that occurs to Captain Cook's compass when he sailed up to the east coast of Australia in 1770.

Besides the traditional recreational packages, the new approach may include prompt hope to the natural, historic and cultural heritage preservation, along with the health-inducing: life quality, welfare (mood, performance, relaxes, detoxic), medicine indications (metabolism, respiratory and circulatory systems), elderly care and chronic diseases treatments.

### **Conclusion and Future work**

The paper offers a brief recapitulation of the global Earth magnetic field, especially the so-called Schumann resonance and its effects on humans and their health. Although being first mentioned in the middle of the last century, many issues related to the Schumann resonance have not been deeply investigated. Some exceptions are noted in the findings related to

the major influence on the Earth's weather, the global temperature and the climate change indicator. This study also briefly informs about the scholars who argue the influence of the Schumann resonance on the brain and heart activity, heart rate and blood pressure.

The increased industrialization and the development of hugely populated areas pollute and strongly suppress the naturally existing electromagnetic fields with extremely low frequencies. Consequently, there is an increase in the number of people suffering from various neurological disorders, starting from the mild ones, like depressions, apathy, losing the working ability, spreading over the more aggravating ones, like Alzheimer's and Parkinson's neurological deceases. On the other side, the economic and social development derived other phenomena like aging and high health care costs, thus provoking the health to be one of the driving forces for tourism development. Traveling for the sake of health, recreational activities associated with health constantly initiates new market demand urging tourism market to create new products and services labeled with health and wellbeing.

Hence, the focus of this paper is on the possible influence of such permanent Earth's magnetic fields on the health and well-being of those who visit, sightsee or stay at some recreational, tourist and leisure environment. Particular attention is raised within the optional utilization of the low-frequency electromagnetic fields in recreational areas that are used for tourism and relaxing purposes. The study adds to the current literature that already argues that the Schumann resonance fields have a high influence on human behavior, well-being, and health conditions. Thus, exposing people to such electromagnetic fields could improve their health, along with society in general.

In some future work, this study may be improved by discussing results from various measurements of the Schumann resonance fields at carefully selected sites, such as recreational resorts, spa and wellness centers, tourist complexes, well-visited attractions, cultural heritage and religious spots, like churches and monasteries, etc. So, the future work may address specific measurements of the low frequency in selected places where visitors *'feel'* relaxed and rejuvenated. Then, to compare gathered data with other populated and ordinary places where people live and work in the line of identifying the reasons why some places suite better for relaxation than others. Hence, future work may be expanded by measuring the intensity and duration of the Schumann resonance

frequencies in those areas that are responsible for beneficial influence on the people's health and well-being. Progress on Schumann resonance knowledge related to recreational and environmental health, wellness and sustainable tourism applications are further expected for tourism destinations.

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