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THE ESSENTIAL ENVIRONMENTAL CAUSE OF MULTIPLE SCLEROSIS DISEASE

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Abstract—The essential cause of Multiple Sclerosis (MS) remains to be unknown until present. Although the relevance of racial, genetic, immunological and environmental causal factors has been accepted and expressed by various researchers, there has not been an elaborate study as to the essential cause of MS. This study aims to explain the importance of the environmental causal factor on the occurrence of MS compared to the racial, immunological and genetic factors. In this study, especially the Extreme Low Frequency (ELF) electromagnetic fields and electromagnetic fields at a frequency band (10^9–10^{13}) Hz in terms of dielectrophoretic effect on myelin in dispersive gray matter and white matter are regarded as the essential causal factor of MS regardless of the fact, whether their sources are artificial or natural. There are epidemiological and experiment-based studies that support this view. In order to support my view, I made use of several comparative studies and obtained computational data. Dielectrophoretic force in the human body, especially in gray and white matter can affect on the myelin basic proteins and be the cause of accumulating them.

1. INTRODUCTION

Multiple sclerosis (MS) is one of the most common neurological disorders whose symptoms occur as a result of the inflammation and breakdown in myelin. Myelin is made of lipids of proteins and protective layers of nerve fibers. It insulates the nerve fibers found in the central nervous system (CNS) and the peripheral nervous system

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(PNS) by surrounding them. Demyelination is a degenerative process that erodes away the myelin sheath. This process may be compared with the loss of insulating material around an electrical wire. The electrical signals traveling along the nerves decelerate, that is, become slower and interferer. When nerves are affected, the patient experiences a progressive interference with the functions that are controlled by the CNS such as vision, speech, walking, writing, attention and memory.

In the recent years, researchers, national and international organizations have focused on the disorder of the immune system [1], genetics [2–4] and environmental factors [5, 6]. Most of researchers found that the high intake of vitamin D is associated with lower prevalence rates of multiple sclerosis [7]. There are various studies regarding the prevalence, diagnose and treatment of the MS disease in the world [8–11]. The epidemiological studies on MS worldwide have been realized by the World Health Organization (WHO) and the Multiple Sclerosis International Federation (MSIF) [12]. However, there was no clear information and explanation about the main cause of multiple sclerosis in the literature. According to the last report of the WHO and MSIF dated by 2008, the median estimated prevalence of MS is 30 per 100000 and the median estimated incidence 2.5 per 100000 globally. The median estimated prevalence of MS is greatest in Europe (80 per 100000), followed by the Eastern Mediterranean (14.9), the Americas (8.3), the Western Pacific (5.0), South-East Asia (2.8) and Africa (0.3) and by income category, the median estimated prevalence of MS in greatest in high income countries (89 per 100000) followed by upper middle (32.0), lower middle (10.0) and low income countries (0.5). The last result with respect to incomes of countries denotes that the median estimated prevalence of MS is lower among the low income countries where electricity is less consumed. However, besides the fact that most of the low income countries are located in the southern hemisphere, they lack the conditions suitable for the occurrence of MS such as African and south American countries. In this study, dielectrophoretic force in the human body, whether its source is artificial or natural, has been found as the causal factor of MS disease. The supporting arguments and details have been explained by considering of the results of electric field distribution due to natural or artificial electromagnetic sources around and in the human body, and the epidemiological studies on MS. Therefore, MS disease is not a modern day disease and has increased depending on uncontrolled electromagnetic technologies and sources.

2. METHODS

2.1. Dielectrophoretic Force

Dielectrophoresis is a phenomenon that comes into consideration where the suspended particles in a fluid are moved towards the regions of high electric field strength or repelled from them. Dielectrophoretic force is stronger at regions of high electric field variations. In case that the electric field is uniform, the polarized neutral particle doesn't move in electric field (Fig. 1). Dielectrophoresis can be used to manipulate, transport, separate and sort different types of particles [13].

Our purpose here is to find out the dielectrophoretic force affecting on lipids of proteins (seventy to 80% of the dry weight of myelin consists of lipids [14]) or protective layers of nerve which are assumed as a spherical neutral particle for simplicity in the white and gray matter media. Here comes the question in mind, whether dielectrophoretic force can separate the lipids of proteins from nerve tissue by the electric field in human body.

For spherical particles like myelin, the time-averaged DEP force is given by [15]

$$\mathbf{F}_{DEP} = 2\pi r_p^3 \varepsilon_0 \varepsilon_m \mathrm{Re}[K(\omega)] \nabla(E^2) \tag{1}$$

where r_p is the particle radius, ε_0 is the permittivity of free space, ε_m is the real part of the permittivity of the suspending medium, and $\mathbf{E}$ may be replaced by $\mathbf{E}_{rms}$ that is the root mean-square electric field. The Clausius-Mossoti factor $K(\omega)$ depends on the complex permittivity of both the particle and the medium and is a measure of the effective polarizability of the particle. When $\mathrm{Re}[K(\omega)] > 0$,

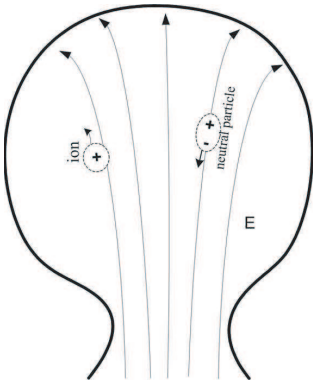

Figure 1. Dielectrophoretic field affecting on an ion and a dielectric particle in schematic of human head.

particles are attracted to regions of stronger electric field when their permittivity exceeds that of the suspension medium. This is called positive dielectrophoresis (p-DEP). When permittivity of medium is greater than that of particles, this results in motion of particles to lower electric field ($\mathrm{Re}[K(\omega)] < 0$). This case is called negative dielectrophoresis (n-DEP). In the case of spherical particles, Clausius-Mossoti factor is given by

$$K(\omega) = \frac{\varepsilon_p^* - \varepsilon_m^*}{\varepsilon_p^* + 2\varepsilon_m^*} \tag{2}$$

where $\varepsilon^*_{i(i=p,m)}$ is the complex permittivity of the particles and surrounding medium; and $\varepsilon(\omega)_i$ is the permittivity of the particles and surrounding medium, which are, respectively;

$$\varepsilon^*_{i(i=p,m)} = \varepsilon(\omega)_i - j\frac{\sigma_i}{\varepsilon_0 \omega} \tag{3}$$

$$\varepsilon(\omega)_i = \varepsilon_{i\infty} + \sum_{n=1}^{4} \frac{\Delta\varepsilon_{in}}{1 + (j\omega_n \tau_{in})^{\alpha_{in}}} \tag{4}$$

where the indices p and m refer to the particle and the surrounding medium, respectively. The values ε and σ are the permittivity and the conductivity of the medium, respectively, n is the number of dispersion regions, τ is relaxation time, ε_∞ is the relative dielectric permittivity at high frequency range, $\Delta\varepsilon_n$ are the differences of relative dielectric permittivity between high and low frequencies in the nth dispersion regions ($n = 1, 2, 3, 4$) [16–27], ω is the angular frequency of the applied field ($\omega = 2\pi f$), and $j = \sqrt{-1}$.

If a nerve cell is located in a non-uniform electric field, regardless of whether produced by a natural based source or an artificial, as shown in Fig. 2.

Then the dielectrophoretic force affecting on lipids of proteins that are located in the white and gray matter can be found by using the Clausius-Mossoti equation for different dispersion regions. Figs. 3 and 4 show the calculated repulsive dielectrophoretic force affecting on a particle of the myelin basic protein (MBP) at frequencies 0–10^5 Hz and

Figure 2. Schematic of nerve cell and dielectrophoretic force affect on MBP.

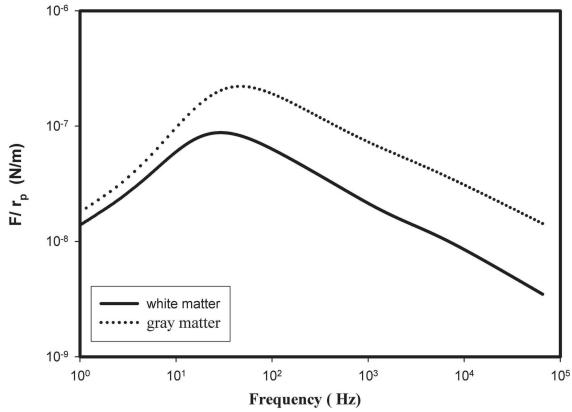

Figure 3. Variations of dielectrophoretic force, affecting on MBP in white and gray matter, with respect to frequency, $(10^0$–$10^5)$ Hz.

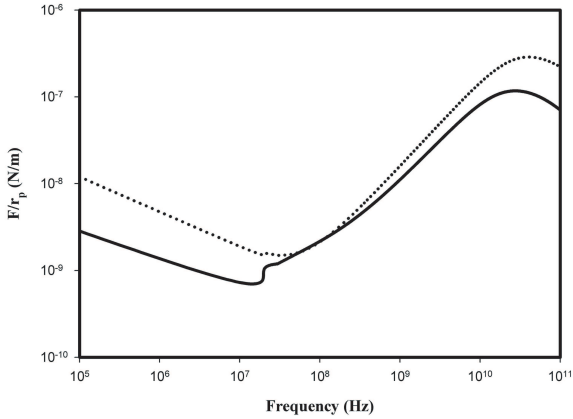

Figure 4. Variations of dielectrophoretic force, affecting on MBP in white and gray matter, with respect to frequency, $(10^5$–$10^{11})$ Hz.

10^5–10^{11} Hz respectively, at distance of $r = 2$ nm for the electric field intensity of $E = 5000$ V/m.

This dielectrophoretic force reaches its peak levels at frequencies 50 Hz and 40.6 GHz in the gray matter, at frequencies 29 Hz and 28.156 GHz in the white matter. If we consider the MBP with a molecular weight of 18.5 kDa and the radius of $r_p = 1.525$ nm and the adhesion force of $F/r_p = 0.05$ mN/m between MBP and fiber cell [14], the dielectrophoretic force at these frequencies and around these frequencies is capable of separating the MBP from the nerve cell under long term exposure conditions.

As an example to dielectrophoretic force affecting on human body, the results of the study by Chen et al. [28] and Kaune and Forsythe have been considered [29]. The comparison of the theoretical results by Chen et al. to the experimental results of Kaune and Forsythe on vertical and horizontal current densities for a grounded human model exposed to an electric field of 10 kV/m and frequency of 60 Hz is given by Chen et al. [28].

According to this study, the induced current densities for a realistic model of a man with a height of 180 cm and weight of 68.2 kg standing upright and in direct contact (short-circuited) with the ground, and who is exposed to a 60 Hz electric field of 10 kV/m is shown in Fig. 5. If the human body is short-circuited with the ground (Figs. 6(a), (b)), the induced current density ($\mathbf{J}$ (nA/cm^2)) on the human body would be less with respect to the case in which the human body is not short-circuited (Figs. 6(c), (d)). The distribution of electric field ($\mathbf{J} = \sigma\mathbf{E}$) is non-uniform in the human body. Because of the non-uniform electric field distribution in the human body, the charged particles will move along the electric field lines and the neutral particles will be polarized forming a dipole and will be pulled towards the strongest electric field region.

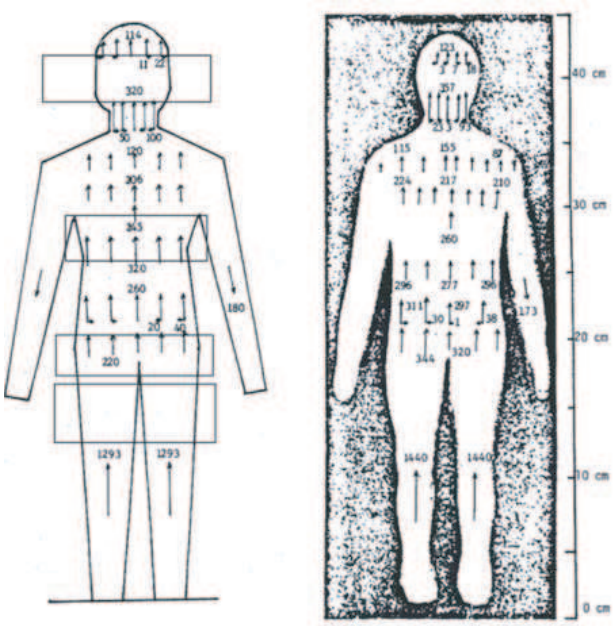

Figure 5. Distribution of induced current density (nA/cm^2) in human body; (a) theoretical (Reproduced [28]), (b) experimental [29].

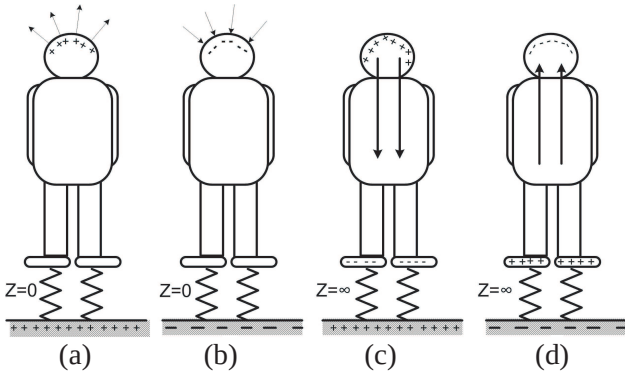

Figure 6. Human body in an electrified medium, (a), (b) The impedance Z (Ohm) between human body and ground (short-circuit) is equal to zero in other words, the human body is protected against the electromagnetic field; (c), (d) The impedance Z (Ohm) between human body and ground is not equal to zero in other words, the human body is not protected against the electromagnetic field.

The current density distribution induced by the electric field on the body model has to give indications about which parts in the body can be affected and show more symptoms of MS disease compared to other parts. Looking at the Fig. 5, we may expect possible symptoms from the degeneration of nerves point of view, in the affected parts of the body with respect to the degree of the gradient of electric field strength especially on the femur, genital organs, spinal cord, cerebellum, visual cortex, heart and lungs.

2.2. Where Do We Live?

There are four forces in the universe. Every physical process occurs as a result of one of these forces. The greatest known force is the strong nuclear force (SNF) that holds protons and neutrons together within an atomic nucleus. The second greatest force is the electromagnetic force (EMF). EMF is 137 times weaker than SNF and in the form of electrical and magnetic forces acting between charged particles. EMF can be expressed briefly by Lorentz force

$$\mathbf{F} = Q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{5}$$

where Q, $\mathbf{E}$ and $\mathbf{v}$, and $\mathbf{B}$ are the electric charge (C) of particles, the electric field intensity and the velocity of particles, and the magnetic field intensity, respectively.

The third force is the weak nuclear force (WNF) that is 10^5 billion times weaker than SNF. The weakest of the forces, the force of gravitation, is so small that if we let an entire ocean represent the size of the weak force, then gravitation would be as big as a single drop of water. Despite the weakness of it as stated above, the gravitation force still remains the most significant force in our daily lives. The second effective force field in the universe, EMF, is produced by natural sources such as lightning, charged clouds, electrosphere, earthquake (piezoelectric), streaming potential, magnetotelluric fields, interactions of the sun winds with magnetic fields of the earth etc, and artificial sources such as high voltage power lines, base stations, every electric and electronic equipments, mobile phones, radars, radio and TV transmitters, wireless systems etc. The magnitudes, frequencies and exposure time of the radiated power from all natural and artificial sources may be different from each other. So, the resultant field at the observation point will depend on both the conditions of medium (electrical parameters of medium, geometry, time) and the specifications of electromagnetic sources (polarization, power, frequency, location). At this point, we should consider which sources are effective on human body in short- and long term exposure conditions. We are living in a big EMF produced by the complex sources. The genetic structure of the human body will also interact and take its form depending on the total electric field intensity on the world.

3. FUNDAMENTAL EMF SOURCES

3.1. Electrosphere and Magnetosphere

The electromagnetic eigenmodes of Earth-ionosphere spherical resonator known as Schumann Resonances (SR), predicted by W. O. Schumann in 1952 [30] are excited by global lightning activity. The Schumann Resonance is a set of spectrum peaks in the ELF portion of the Earth's electromagnetic field spectrum. The nominal average frequencies observed are 7.8, 14, 20, 26, 33, 39, and 45 Hz with slight diurnal variation. The electrical resistivity of the atmosphere decreases with respect to height and at an altitude of about 50 kilometers remains constant, where the potential difference between the place and the Earth's surface is about 3×10^5 V. This region is known as the electrosphere (Fig. 7(b)). The magnetosphere of the Earth is a region in space whose shape is determined by the extent of Earth's internal magnetic field generated by a dynamo process of the Earth, the solar wind, plasma, and the interplanetary as shown in Fig. 7(c).

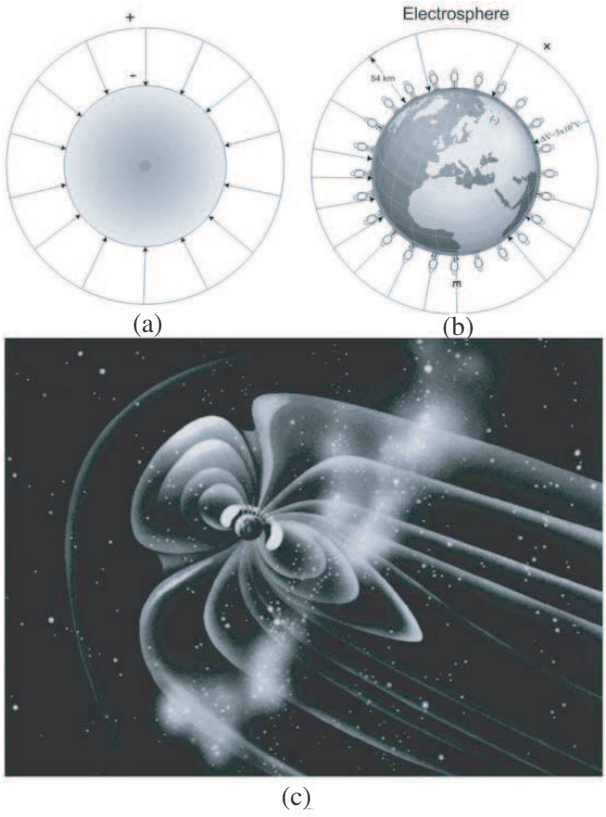

Figure 7. (a) The equivalent spherical capacitor. (b) The earth and electrosphere. (c) The magnetosphere.

3.2. Lightning and MS Disease Relation

Lightning discharges are powerful impulsive sources of electromagnetic power from a few hertz to several hundred mega hertz and the bulk of the energy radiated in the frequency bands < 30 kHz. The energy released by the lightning discharge occurs acoustically (thunder), optically (lightning), and electromagnetically [31–33]. Lightning provides, result of electrical discharge from cloud to cloud or from a cloud to ground, minimization of potential gradient. This event is considered to be a very important subject from MS disease point of view. For this reason, after lightning the local electric field intensity approaches the fair atmospheric electric field intensity level. As a result of this, a relaxed medium occurs. The average annual number of thunderstorm days or hours for a given locality (keraunic level) is shown in Fig. 8 [34].

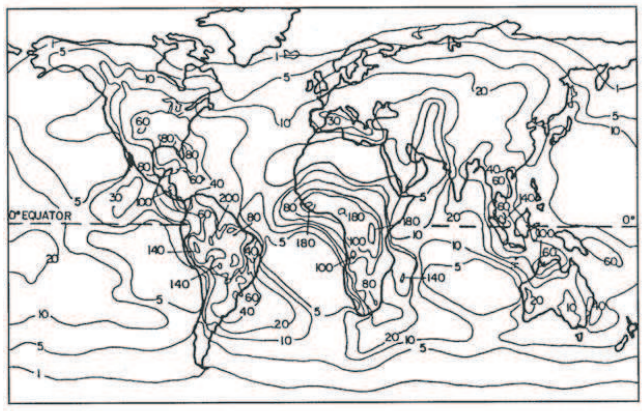

Figure 8. The keraunic map [34].

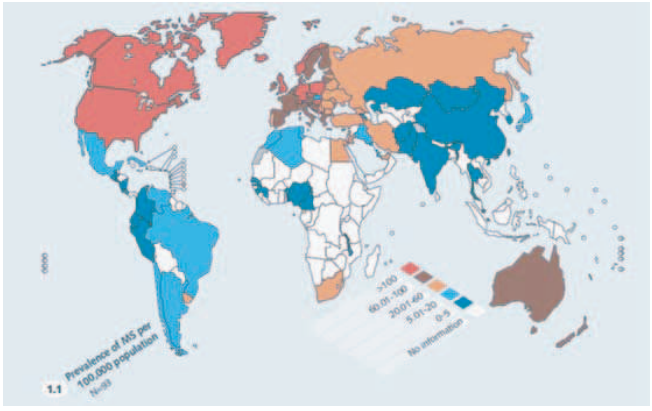

Figure 9. The distribution of MS in the world [12].

If a region has a low keraunic level and very cloudy climate conditions, the atmospheric electric field intensity level will be higher than the fair atmospheric electric field intensity level [35]. Taking into account the comparative interpretation between keraunic map (Fig. 8) and the map showing the distribution of MS in the world (Fig. 9), where high atmospheric electric field intensity and lower number of lightning strokes are seen (approximately the number of lightning stroke 10), there MS disease is more frequent. Contrary to this, where lower atmospheric electric field intensity and higher

number of lightning stroke are seen, less MS cases are expected. The comparison of the keraunic map (Fig. 8) with the epidemiological map (Fig. 9) and the consideration of the aforementioned data support my hypothesis. Higher residential areas with generally cloudy weather, as shown in Fig. 10 have a maximum gradient of total electric field intensity compared to regular places, so these areas have a triggering effect on the occurrence of MS disease. Some residential areas that have intensive electric field such as around the power lines, electrical equipments and conductive structures have a triggering effect from MS disease angle of view.

The variation of atmospheric electric field intensity at a residential place depends on climate conditions, solar activity, topographical structure and conductivity of the surface, nearby objects, man made electrical sources, and close thunderstorm activities.

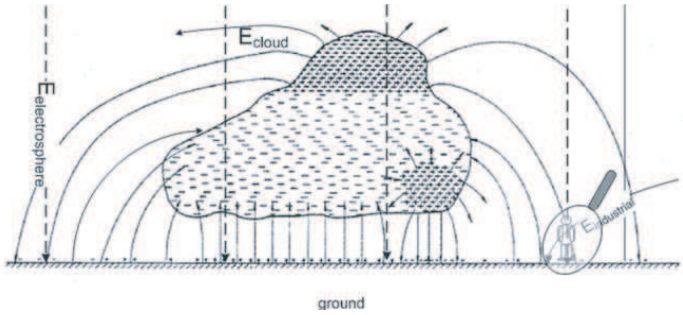

Figure 10. Fair weather electromagnetic field and disturbing electromagnetic fields.

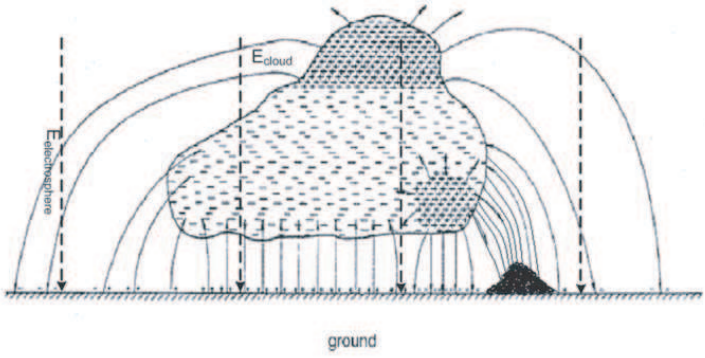

Figure 11. The variation of electromagnetic field of a cloud with respect to local variations of topography of ground.

Fair weather electric fields are disturbed by the electrical activities explained in Figs. 10 and 11. The atmospheric electric field intensity is directed downwards. Under normal conditions and in the pure air, the electric field intensity close to the ground surface is about 100–200 V/m [35]. In presence of an electrified cloud, the electric field can reach up to electric field of 10 kV/m. In fact, the important and interesting point is that if in a place, the number of lightning strokes per year is small and the weather is usually cloudy, that is, the electrification is not sufficient to realize a lightning stroke; the electric field intensity is lower than the maximum electric field level necessary to start a lightning. In this condition, the electric field intensity increases and remains approximately constant at high level during the cloudy days. It can be considered as if people are living within a big capacitor during the cloudy days. In order to avoid the long term effects of the outer electromagnetic fields, either they should comply with the shielding and grounding rules of electromagnetic fields or take measures to keep away from the high electromagnetic fields at ELF and UHF-SHF frequencies. If the electric field intensity and exposure time is higher, the MBP can be separated from the nerve cell at every frequency even at optic frequencies.

4. RESULTS

In order to verify the fact that dielectrophoretic force produced by natural or artificial electromagnetic field sources operating at ELF and UHF-SHF especially about 50 Hz and 10^9–10^{13} Hz are the main causal factors of MS disease, first of all, it has been considered the Clausius-Mossoti equation in dispersive and real brain electrical parameters conditions. It has been shown that the dielectrophoretic force is capable of separating the lipids of proteins from nerve cell by the electric field in human body. The computational results have been compared to the epidemiological studies in the world. In this study, the specifications of our environment both from microscopic scale such as myelin-nerve cell scale and macroscopic scale in other words global scale have been considered together. It has been tried to tackle the question "Which electromagnetic field distribution conditions may be considered as the background, in other words, essential cause for the MS disease?".

The most important correlation between the MS disease and natural electromagnetic fields can be determined by evaluating the last report of the WHO and MSIF in 2008 (Fig. 8) and comparing them with the keraunic map (Fig. 9). According to the comparison of Fig. 8 with Fig. 9, some places on the Earth have

electromagnetically intensive field, for instance mostly cloudy places, will be disadvantageous on human body from MS disease point of view. Therefore, these places can be regarded as risky places. Additionally, the risk will increase where these places cover artificial electromagnetic sources at frequency of 50 Hz and at frequency band of 10^9–10^{13} Hz.

5. DISCUSSION

In this study,
1-It has been explained and proven that high ELF field and UHF-EHF field whether produced by natural sources or by artificial sources is a fundamental causal factor of Multiple Sclerosis.

a- According to the result of the Clausius-Mossoti equation, the coagulation of the lipids of proteins will be more effective in gray matter with respect to white matter that is, the coagulation of the lipids of proteins can be observed by a phase delay in these media. However, the volume of gray matter is smaller than the volume of white matter.

b- As a result of the dielectrophoretic effect of electromagnetic fields, GSM mobile phones [36] and PDAs emitting both pulsed radio waves (from the antenna) and ELF fields (from the battery circuits) are hazardous to human health. These fields are able to separate and coagulate calcium, enzyme and other useful molecules from the surfaces of cell membranes. The calcium ions bound on the surfaces of cell membranes are vital in maintaining their stability. In lack of these ions, the cell membranes are weakened.

2-The prevalence of MS depends on the living place conditions on the earth:

a- If a residential place has high electric field strength (regardless of its source) at ELF frequencies about 50 Hz and at UHF-SHF frequencies 10^9–10^{13} Hz, this residential place has risk factor for living along the adolescent era from MS point of view. However, one should keep in my mind that it is most of the developed countries that have extra electromagnetic field sources at frequency bands ELF and 10^9–10^{13} Hz.

b- People living in the same region can be affected by the electric fields in different forms and degree depending on the varying topographic and environmental factors.

c- People living in higher places with mostly cloudy weather may be affected by MS disease at a greater degree compared to the ones living at places located on plain ground.

d- If people living in places having low risk factor from MS point of view, such as middle of the Africa, South America etc. migrate and start living in places with high risk factor from MS point of view for a long time, then these people may be more easily affected by MS compared to people coming from other regions of higher risk factor from MS point of view.

e- If people have to live in a place with high electric field for a long time, they should take the necessary measures such as displacement, away from electromagnetic sources, walking and physical activities to minimize the effects of the electric field.

f- Even though there hasn't been done any epidemiological study on MS in most of the African countries in Fig. 9, according to my hypothesis, one may expect blue and dark blue colors as the colors of these countries from MS angle of view which means that in the referred countries MS disease will be rarely observed. If the keraunic map (Fig. 8) is considered, it can be understood clearly why the region in the south of Africa is shown by orange color.

g- If a place has cloudy climate conditions and the number of lightning strokes in this place is smaller than approximately 10, then this place can be considered as a risky place from MS point of view.

3-The gradient of electric field strength in the body is higher around femur (especially, right at this place the gradient of electric field is found the highest), spinal cord, cerebellum, visual cortex, genital organs, hearth and lung region; for this reason some diseases like Leukaemia, Alzheimer, Parkinson [37] can be resulted from the gradient of electric field strength. These diseases should be investigated from an electromagnetic effect angle of view in the future.

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