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Experimental and Numerical Simulation of Mobile Phone Base Station Radiation effects on Children Blood Interaction and Therapeutic Role of Olive Oil

تجربة عملية ومحاكاة لتأثير إشعاع محطات إرسال الجوال على دم الأطفال والدور العلاجي لزيت الزيتون

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إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **محمد عبدالله أحمد ابو جامع** لنيل درجة الماجستير في **كلية *العلوم*** قسم **الفيزياء** وموضوعها:

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Experimental and Numerical Simulation of Mobile Phone Base Station Radiation Effects on Children Blood and Therapeutic Role of Olive Oil

وبعد المناقشة العلنية التي تمت اليوم الثلاثاء 24 شوال 1438هـ، الموافق 2017/07/18م الساعة العاشرة صباحاً في قاعة مؤتمرات مبنى القدس، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في **كلية *العلوم*/** قسم **الفيزياء**.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

أ.د. عبدالرؤوف علي المناعمة

Abstract

Several recent studies have indicated that global system mobile communications (GSM) radiation have an adverse health effect on cells of human beings. As there is a significant increasing growth in the use of mobile telecommunications services in the Gaza Strip, which leads to increase in the number of base station locations. The purpose of this thesis is to study the effect of microwave frequency emitted from mobile phones base stations antennas on children blood. We studied the effect of the radiation emitted on the blood, liver, kidney and thyroid stimulated tissue by simulation electromagnetic waves using Finite-difference time-domain method (FDTD) by MATLAB software program. Electric and magnetic fields, Specific Absorption Rate (SAR) and power density have been drawn with respect to time steps and evaluate experimentally the biochemical parameters and the blood picture in these tissues of the chlidren and therapeutic role of Olive oil. Total of 120 children (6-12 years) were divided to three groups. The first group served as control group. The second group exposed to electromagnetic field (E.M.F), the third group exposed to E.M.F of and given 2.5 ml/day Olive oil supplementation for 5 weeks. The second and the third groups lived nearby mobile phone base station (100-150 m). Electromagnetic field exposure increased the concentrations of serum glucose, triglycerides, total cholesterol, albumin, urea, uric acid and creatinine but total protein, globulin and Thyroid-Stimulating Hormone (TSH) were decreased. Activities of serum aspartate a minotransferase (AST), alanine a minotransferase (ALT), alkaline phosphatase (ALP) and bilirubin were increased. Concerning hematological parameters, the more obvious changes were observed in the increment of WBC, lymphocyte, MCV, MCH, MCHC, and decrease in hematocrit, Hb, RBC, and PLT count in response to the exposure to E.M.F. Improvement after supplementation suggests that Olive oil can ameliorate hazards of such radiation on hematological and biochemical indices.

Key words: Eectromagnetic field, Non-ionizing radiation, base station, Finite difference time domain, Blood indices, Liver and Kidney functions, Olive oil.

الملخص

يتزايد النمو في استخدام خدمات الاتصالات المتنقلة في قطاع غزة بشكل ملحوظ، هذا النمو يؤدي الى زيادة حتمية في عدد مواقع المحطة الأساسية لتقوية الإرسال. تهدف هذه الأطروحة إلى دراسة تأثير موجات الميكروويف المنبعثة من محطات تقوية الإرسال على دم الأطفال باستخدام المحاكاة والتجربة العملية. بواسطة برنامج الماتلاب تم رسم علاقة بيانية تبين المجال الكهربي والمغناطسي والقدرة على الامتصاص ومعدل الامتصاص النوعي خلال التعرض للموجات الكهرومغناطسية الصادرة من محطات الجوال بطريقة المجال الزمني الفرقي المحدود، خلال التجربة العملية قمنا بفحص المعاملات البيوكيميائية لهذه الأنسجة وصورة الدم للجسم البشري كما درسنا العمل العلاجي لدور زيت الزيتون على الأطفال المعرضين لهذه الإشعاعات. الناحية العملية كان تهدف لدراسة بعض المقاييس على دم ١٢٠ طفل من الذكور تتراوح أعمارهم من ٦-١٢ سنة ويقيمون على بعد ١٠٠-١٥٠م بالقرب من هذه المحطات ولمدة أكثر من ٥ سنوات، تم تقسيم الأطفال الى ٣ مجموعات، المجموعة الأولى تعتبر المجموعة الضابطة، أما المجموعة الثانية تعرضت للموجات الكهرومغناطيسية، أما المجموعة الثالثة تعرضت لنفس الموجات مع إضافة زيت الزيتون ٢,٥ مل يوميا لمدة ٥ أسابيع، أكدت الدراسة أن تعرض هؤلاء الأطفال للموجات الكهرومغناطيسية فقط يحدث نقصا في سكر الدم والبروتينات الكلية والجلوبيولين وهرمون المحفز للغدة الدرقية بينما ازداد معدل الكوليسترول والدهون الثلاثية والزلال واليوريا وحمض البوليك والكرياتينين والفوسفاتيز القلوي والبيليروبن والمجموعة الناقلة لمجموع الأيض. بالنسبة لصورة الدم أظهرت النتائج زيادة واضحة في كرات الدم البيضاء والخلايا الليمفاويةMCV و MCHC و MCH وقد حدث نقص في كلا من الهيماتوكريت والهيموجلوبين وكريات الدم الحمراء مقارنة بالمجموعة الضابطة. إعطاء زيت الزيتون للمجموعة التي تعرضت للإشعاعات أدى إلى تحسن في معظم القياسات السابقة.

الكلمات المفتاحية: المجال الكهرو مغناطيسي، الإشعاعات الغير مؤينة، محطات التقوية، سكر الدم، صورة الدم، الزلال، مصل الدم، الهرمون المحفز للغدة الدرقية، وظائف الكلى والكبد، زيت الزيتون.

Dedication

I would like to dedicate this thesis to

my parents

my brother

my sisters

my friends

my dear teachers

each person that has supported me

Acknowledgment

I would like to express my special thanks and gratitude to Dr. Khitam Y. Elwasife without her assistance and dedicated involvement in every step throughout the preparation of this thesis would have never been accomplished. Really her supervision was invaluable.

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Introduction

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Introduction

Mobile phones base stations are now an integral part of modern telecommunications. In many countries, over half the population use mobile phones and the market is growing rapidly. The overall goal of this study is to investigate the harmful effects on the blood indices of children theoretical and experimental and therapeutic role of Oliveoil role in the treatment of bio-chemical parameters in children exposed to electromagnetic waves from transmission station. This thesis divided into five chapters, chapter one is an introduction, which give an overview about Electromagnetic waves, Electromagnetic spectrum, Microwave Frequency, Effects of Radio Microwave Radiation, Basic Electromagnetic Wave Properties, Mobile Phone Base Stations and cellular system, Base station network, Chapter two presents a brief about Finite Difference Time Domain and Maxwell's Equations. Chapter three describes Numerical simulation study. Chapter four includes Experimental Method for study. Finally, Chapter five presents the Conclusions and Recommendations.

1.1 Electromagnetic Waves

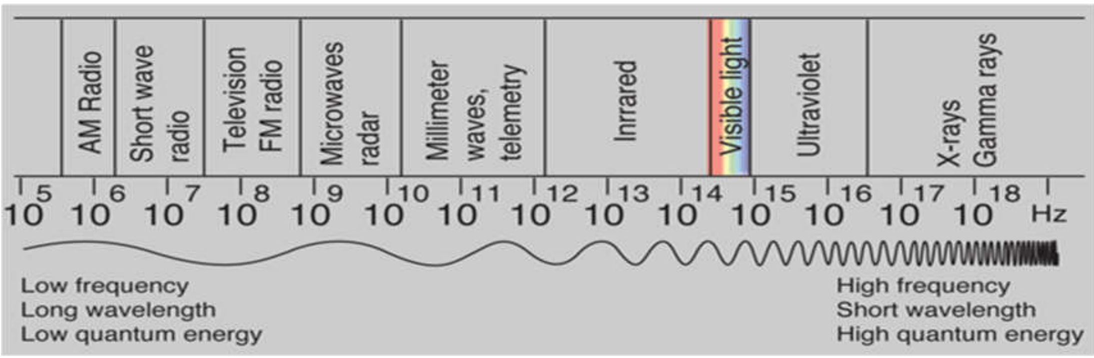
Electricity and magnetism were once thought to be separate forces. Even appeared a unified theory of electromagnetism. The study of electromagnetism deals with how electrically charged particles interact with each other and with magnetic fields has been studied by Scottish physicist James Clerk Maxwell in 1873. There are four main electromagnetic interactions:

- The force of attraction or repulsion between electric charges is inversely proportional to the square of the distance between them.
- Magnetic poles come in pairs that attract and repel each other, much as electric charges do.
- An electric current in a wire produces a magnetic field whose direction depends on the direction of the current.
- A moving electric field produces a magnetic field, and vice versa.

Maxwell also developed a set of formulas, called Maxwell's equations, to describe these phenomena (Lucas, 2015).

1.2 Electromagnetic waves and spectrum

A continuous range of wavelengths called the electromagnetic spectrum. Many types of radiations which depending on their frequency and wavelength that occur in different parts of the spectrum have many uses and hazard (Merlen, 2004). Since the wavelength and the frequency of the wave are inversely proportional to each other. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of electromagnetic radiation (EMR) that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays as shown in below figure.



Figure(1.1): Electromagnetic spectrum represents graphically (Andrews, 2009).

1.3 Types of Electromagnetic Radiation

Scientists have classified the radiation into two main types according: ionizing radiation and non-ionizing.

1.3.1 Ionizing Radiation

Electromagnetic radiation, which has enough electromagnetic energy to strip atoms and molecules from tissue causing a change in chemicals during interaction with the atom, is called ionizing radiation (Khan & Gibbons, 2014). This radiation can cause damage to DNA inside cells, which in turn can lead to cancer, birth defects and genetic defects through DNA mutations caused by the ionization of the atom and molecule ionization. Examples of ionizing radiation are x-rays and gamma rays (Lavin, 2006; A. D. Martin, Harbison, Beach, & Cole, 1986; Rehani & Ortiz-Lopez, 2006)

1.3.2 Non-Ionizing Radiation

This type of radiation does not carry enough energy to ionize any atoms or molecules. For examples of non-ionizing radiation are radio waves, microwaves, infrared, visible light waves, television, stations cellular telephones, Global positioning systems, FM and AM radio are non-ionizing radiation (Mohril, Sankhla, & Chaturvedi, 2016). There are other forms include the earth's magnetic field, as well as magnetic field Also be exposed from proximity to transmission lines, electric appliances and household wiring. These are known as extremely low-frequency (ELF) waves and not considered a directley threat to human health (Introduction to Radiation, 2012; Repacholi & Greenebaum, 1999). Non-ionizing radiation can produce non-mutagenic effects such as inciting thermal energy in biological tissue that can lead to burns. Previous studies showed that non-ionizing radiation does not damage genetic material (DNA) in molecules directly and cannot cause cancer (Turner, 2008).

1.4 Microwaves Frequency

Microwaves are part of the spectrum of electromagnetic waves that we not feel it, which have a wavelength ranging from one meter to one millimeter. These waves use fixed and mobile radio broadcasting, such as radio, television, cellular communications and navigation, to control all the devices humans send to planets, the world of space, computer networks and many other applications (Goldsmith, 2005).

1.5 Effects of Microwaves Frequency Radiation

The rapid growth in wireless communication has raised concern about the risks of microwaves to widespread, where there are microwaves everywhere around us causing concern that some forms of non-ionizing radiation may have biological effects. Which can lead to cancer in some circumstances, researchers studied the impact of these waves and their risks to human health of biological studies. Radiation, which includes radio waves and microwaves is located at the end of the low power of the electromagnetic spectrum as shown in figure (1.1) because it has less energy for other types of non-ionizing radiation, such as visible light and infrared radiation which have sufficient energy to transport the atoms in a molecule around it or cause it to vibrate, but not enough to ionize the atom. Researchers have found that the absorption of microwaves in large quantities with enough materials containing water, such as food, fluids, and body tissues, can produce heat. This can lead to burns and tissue damage. Although microwaves radiation does not cause cancer by damaging DNA in cells as ionizing radiation does, there has been concern that some forms of non-ionizing radiation might have biological effects that could result in cancer in some circumstances (Does, 2013). Rahman has been mentioned Radio Frequency Radiation (RFR) exposure from both mobile towers and mobile phones may have possible thermal/non-thermal effects caused by holding Mobile phones close to the body (Rahman, 2011). Largely studied the thermal effect and refers to the heat that is generated due to absorption of (RFR) radiation. Being exposed to the thermal effect could cause cataracts, fatigue and reduced mental concentration (Leszczynski, Joenväärä, Reivinen, & Kuokka, 2002; Woelders et al., 2017). Many scientists interested to study the non-thermal effects of radiation, and they associated with it affecting the cell membrane permeability (Desai, Kesari, & Agarwal, 2009; Lai, Chan, & Singh, 2016).

Researchers have classified the Effects of Radio Frequency Radiation into two main types according to Thermal Effect and Non-Thermal Effects.

1.5.1 Thermal Effect

Continuous absorption of microwave waves and radio waves, works on heating of biological tissues. The amount of heating produced in an organism depends on several factors primarily on the intensity or (power density) of the radiation once the system penetrates, on some electrical properties of the biomaterial, and on the efficiency of the body's thermal regulation mechanism (Hyland, 2000). The frequency of the radiation, as opposed to the intensity, is taken into account only in so far as it affects (via size resonance) the ability of the organism to absorb energy from the irradiating field (Gust & Hyland, 2000). The safety standards for exposure to microwave Frequency Radiation are purely based on the thermal effect just while ignoring the non-thermal effects of radiation.

1.5.2 Non-Thermal Effects

Often in most countries, the mobile exposure safety standards are based on the postulate that the only biological effect of ionizing radiation is heating the so-called "thermal effect". Recent scientific studies in this field have demonstrated non-thermal effects existing at a significantly lower radiation level than heating. As cellular responses increase, the appearance of cellular changes in non-thermal intensity levels. This means that we urgently need to modify current safety standards to allow much lower levels of radiation intensity (Kumar, 2010). Team of scientists has been found that certain proteins in human cells change due to the radiation at non-thermal intensity levels. This proves earlier findings of cellular changes in animals (Forgacs et al., 2006; Lantow et al., 2006; Levitt & Lai, 2010).

1.6 Basic Electromagnetic Wave Properties

An electromagnetic wave consists of two fields, an electrical field and a magnetic field at right angles to each other and both which are perpendicular to each other and to the direction of propagation of the wave front (Born & Wolf, 1980). Electromagnetic waves differ in wavelength (or frequency). Electromagnetic field transmission and propagation in a direction that is oriented at right angles to the vibrations of both the electric ($\vec{E}$) and magnetic ($\vec{B}$) oscillating field vectors, transferring energy from the radiation source to for a particular place. As in Figure (1.2) shows oscillating energy fields are mutually Vertical and vibrate in phase following the mathematical form of a sine wave.

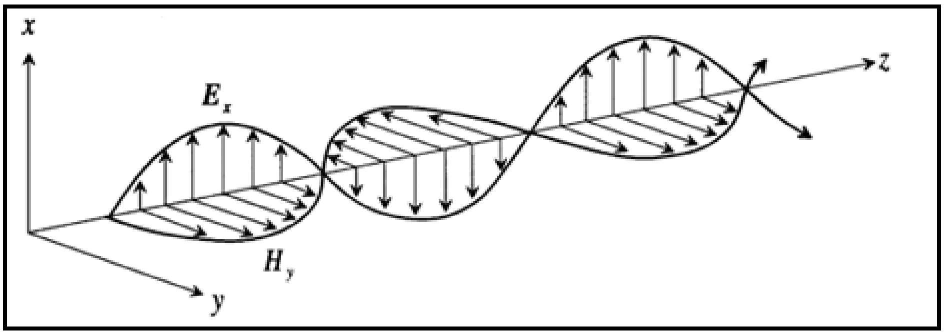


Figure (1.2) : Properties of Electromagnetic Waves (Griffiths, 2005).

All Different forms of electromagnetic radiation share the characteristics and shape of the basic waves, whether they are transmitted to the radio from the broadcasting station, the x-ray of the teeth, the radioactive temperature of the furnace, the burner, or visible light and ultraviolet radiation emitted from the sun, including visible light, oscillates in peaks , and show a wavelength, characteristic amplitude and frequency that defines the energy, direction, and intensity of the radiation (Brooks & Abel, 2007).

1.7 Mobile Phone Base Stations and Cellular System

Since 1990 people using Cellular (cell) phones has been increased significantly, this has been a reason to increase cell phone towers to providing coverage most regions (Townsend, 2002). Cell phone towers or base stations both are true, is a fixed communication site and is part of a network's mobile phone system, its composed of three antennas, two are for receiving and one is for transmitting. Two are used on the receive side so that the base station can compare signals and select the best antenna for each user within the cell mounted on a tower and a building with electronics in it at the base, its function is received and transmitted radio signals such as a mobile phone. Power levels which cell phone towers send it reach a few watts to 100 watts or more, which determines that is the size of the zone that they are created to service it. Often, cell phone towers antenna lengths about a 100 cm and about 20-30 cm its width mounted on high surfaces or towers at a height of (15–50) meters above ground to communication with cell phone users easily, who are often near the ground. actually, its be broad in the horizontal direction, as of the beam narrow vertical spread, the radio frequency field intensity at the ground directly below the antenna is low (Alakija, 1991). These antennae emit Radiofrequency (RF) beams that are typically very narrow in the vertical direction but RF field intensity increases slightly as one move away from the base station and then decreases at greater distances from the antenna (Parsons, 1992).

1.7.1 Type of Base Station

There are many types existing base stations. Each type has a specific use according to the coverage needed:

- **Macro cell**: if the coverage required are large areas such as rural areas and highways we use because it coverage the wide areas also can be increased its performance by increasing the efficiency of the transceiver.
- **Micro cell**: if we need to cover spaces, where a mobile network requires additional coverage to maintain the quality of service to subscribers we used.
- **Pico cell**: its using inside buildings where a mobile network requires additional coverage to maintain the quality of service to subscribers**.**

1.7.2 Base Station Network

A mobile network or cellular network is radio network divided over ground areas Call it the cells as shown in Figure (1.3), each served by at least one stationary site transceiver, known as a base station. Each cell uses a various set of frequencies from adjacent cells, to obviate interference and provide guaranteed bandwidth within each cell when connected with each other, these cells provide radio coverage over a wide geographic region. This enables a large number of portable transceivers (e.g. pagers, mobile, etc.) to communicate together and with stationary transceivers and telephone anywhere in the network, through base stations (Goodman, 1997; Rajesh & Muruganandam, 2013). Radio signals are fed through cables to the antennas and then launched as radio waves into the area, or cell, around the base station. A typical larger base station installation would consist of a plant room containing the electronic equipment as well asthe mast with the antennas (Osahon, Okungbowa, & Ogboghodo, 2013). Several types of antenna are used for the transmissions; panel-shaped sector antennas or pole-shaped omni antennas are used to communicate with mobile phones. Dish antennas form terminals for point-to-point microwave links that communicate with other base stations and link the network together into cells (Velkoski, 2013b). Sometimes the base stations are connected together with buried cables instead of microwave links. Depending on the location of the base station and the level of mobile phone usage to be handled, base stations may be anything from only a few hundred meters apart in major cities, to several kilometers apart in the countryside (Stewart, 2000). Base stations in areas of low mobile phone usage may only have one transmitter connected to their antennas; hence, they will transmit only on one frequency.

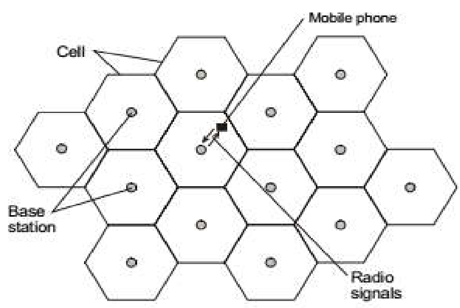


Figure (1.3) : Network of the base stations (Mann, Cooper, Allen, Blackwell, & Lowe, 2000).

Base stations in busier areas may have up to ten or more transmitters connected to their antennas allowing them to transmit on several frequencies at the same time, and to handle communications with many mobile phone (Yacoub, 1993). The power density of each base station transmitter is set to a level that allows a mobile phone to be used within the area for which the base station is designed to provide coverage, but not outside the coverage area. Higher powers are needed to cover larger cells and also to cover cells with difficult ground terrain (Abdelati, 2015). Typical maximum powers for individual macro-cellular base station transmitters are around 5 to 10 watts, although the total radiated power from an antenna could be up to around 100 W with multiple transmitters present. For a low capacity, base station with only one transmitter, the radiated power does not vary over time, or with the number of phone users. Up to seven phone calls can be handled simultaneously by such a base station. With larger capacity, base stations having multiple transmitters, the output power can vary over time and with the number of calls being handle (Bouzouki, Kotsopoulos, & Karagiannidi, 2012). One of the transmitters will transmit continuously at full power, whereas the other transmitters will operate intermittently and with varying power levels up to the maximum as an example, the power density output of a microcellular base station with 10 W transmitters could vary between a minimum of 10 W and maximum of 100 W over time. Microcellular base stations tend to operate at lower power levels around 1 to 2W and have fewer transmitters because of their smaller coverage areas (Mann, Cooper, Allen, Blackwell, & Lowe, 2000).

1.7.3 Beam Shapes and Directions

The radio signals developed by base stations are fed to antennas, which produce beams that are radiated into the cell around the base station. The profile of the beams is carefully chosen by the network planners in order to produce optimal coverage of the cell, but the general principle of beam formation is illustrated in Figure (1.4). The beams formed by antennas used with macrocellular base stations are narrow in the plane of elevation with typical widths between 5º and 10º. The beams are also tilted slightly downwards so the top edge of the main beam is approximately horizontal whereas the lower edge is directed up to 10º below horizontal (Azad & Ahmed, 2010). When considering the heights at which antennas tend to be mounted, this implies that the main beam from base station antennas would be expected to reach ground level typically between 50 and 300 m from the foot of a mast(Kagoshima, Lee, Fujimoto, & Taga, 2001). The antennas used with microcellular base stations have much broader beams in the plane of elevation because they are intended to communicate over much shorter distances.

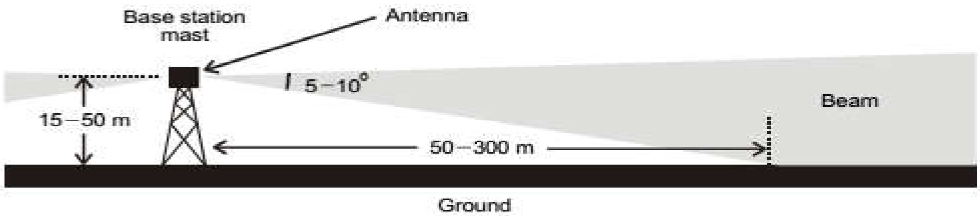


Figure (1.4) : Beam Shapes and Directions Antenna (Mann et al., 2000).

The beams from the antennas spread out with distance and tend to reach ground level at distances in the range (50-300 m) from the antennas. The radio wave levels at these distances are much less than those directly in front of the antennas. At distances closer to the mast than where the main beam reaches ground level, exposure occurs due to weaker beams known as side lobes (Mann et al., 2000).

1.7.4 Exposure Stansdards

At positions where people are exposed to the radio waves from base station antennas, the level of exposure is much more constant over the whole body than when they are exposed to a mobile phone. Under these circumstances, the relevant basic restriction in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines is that placed on Specific Absorption Rate (SAR) averaged over the entire body mass (Bakker et al., 2012). Whole-body SAR is not very easy to measure practically, consequently ICNIRP gives a reference level in terms of the power density below which the SAR restriction would 2 W/ m^2 to 10 W/m^2 for the general public over the radiofrequency range 10 MHz to 300 GHz (Ng, 2003). The reference level is 4.5 W /m^2 in the 900 MHz Global System for Mobile (GSM) frequency band and 9 W/ m^2 in the GSM 1800 frequency band. This is not because a lower limit is set for operators using the GSM 900 band since the underpinning basic restriction is the same for both frequency bands. The different reference levels arise because the body tends to interact more strongly with radio waves at 900 MHz than at 1800 MHz meaning that a lower reference level has to be set. It is important to recognize that the guidelines are intended to limit total exposure to radio waves from all sources and not just that part of exposure arising from a particular base station. (Velkoski, 2013).

1.8 Radiation and Biological Effect

For many years there was a discussion between the public with respect to radio-frequency radiation (RFR) and its biological effects on human organism (Sirav & Seyhan, 2016). Two systems of digital mobile phone commonly used, GSM 900 MHz and GSM 1800 MHz (Panagopoulos, 2011). The electromagnetic radiation is characterized by its frequency, intensity of electric and magnetic fields, their direction and polarization characteristics in free space. The fields inside the tissues of biological body can interact with them and therefore, it is necessary to determine these fields for general quantification of biological data obtained theoretically, When an electromagnetic field falls upon the human body, then it partially penetrates into human body and is attenuated by human body tissues and its parts are absorbed by body tissues (Kaushik & Pathak, 2015). Many researchers have studied the relationship of radio waves and their effects on human health (Jauchem, 2008; Wdowiak, Wdowiak, & Wiktor, 2007). The biological effects of exposure to electromagnetic radiation (EMR) from mobile phones were reported to be variable, depending on many factors including duration of exposure, distance from the various sources, species and tissues as well as the conditions of exposure (Ragy, 2015). Thermal biological effects of microwave radiation have been investigated both from the experimental and numerical viewpoints. Also Taflove & Hagness studied Computation of electromagnetic field inside a tissue at mobile communication, which presents a new approach to calculate the electromagnetic field inside a tissue, composed of electrically excitable cell by means of the Finite-difference time-domain (Taflove & Hagness, 1995).

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Chapter 2

Finite Difference Time Domain (FDTD) and Maxwell's Equations

Chapter 2
Finite Difference Time Domain (FDTD) and Maxwell's Equations

2.1 Introduction

FDTD shortcut referred to Finite difference time domain method is today's one of the most popular method in computational electromagnetics. It's a direct method to Maxwell's equations where the electric fields and magnetic fields are discretized on orthogonal grid points with a half cell offset both in space and time domain. The FDTD is so widely used in the computational electromagnetic field (CEM) community that although finite difference methods cover a wide spectrum of complexity and accuracy, it's the FDTD which is almost always implied in CEM when finite differences are mentioned (Davidson & Aberle, 2010). The Yee's algorithm, as it is usually called in the literature, is well known for its robustness and versatility. The method approximates the differentiation operators of the Maxwell equations with finite-difference operators in time and space. This method is suitable for finding the approximate electric and magnetic fields in a complex three-dimensional structure in the time domain. Many researchers have contributed immensely to extend the method to many areas of science and engineering (Taflove & Hagness, 1995). The FDTD method belongs in the general class of grid-based differential numerical modeling methods (finite difference methods). In 1966, Kane Yee first proposed a method for discretizing Maxwell's equations such that the value of $\vec{E}$ and $\vec{H}$ are sampled at suitable positions of time and space in order to simulate the procedure of electromagnetic propagation in such a way that could be implemented in the time domain and on a computer (Yee, 1966). Because absorbing boundaries had not yet been developed, Yee made his computational region finite by computing the scattering from a conducting post in an ideal conducting cave, with an impulse for an incident wave. Finite difference methods are numerical methods in which derivatives are directly approximated by finite difference quotients.

2.2 Theory of Finite-Difference Time-Domain (FDTD)

The theory on the basis of the FDTD method is simple. To solve an electromagnetic problem, the idea is to simply discretize, both in time and space, the Maxwell's equations with central difference approximations to solve an electromagnetic problem. The allocation in space of the electric and magnetic field components, and the marching in time for the evolution of the procedure thats is the originality of the idea of Yee (Oskooi et al., 2010). We will begin considering a simple one-dimensional problem assume, at this stage, "free space" as propagation medium to understand the theory well (Inan & Marshall, 2011). It can be noticed that the time derivative of the E field is dependent on the Curl of the H field when Maxwell's differential form equations are examined. To illustrate this we know the time derivative of the E field is dependent on the change in the Curl of H field (Rodrigo, 2011). The basic FDTD equation that its the resultant the new value of the E field is dependent on the difference in the old value of the H field on either side of the E field point in space and the old value of the E field therefore, the difference in time. Generally, this is a simple description. But the overall effect is as explained. The H field is found in the same way the new value of the H field is dependent on the difference in the E field on either side of the H field point and dependent on the old value of the H field (Paul, 2008). To implement an FDTD solution of Maxwell's equations. First, must establish a computational domain, simply the physical region over which the simulation will be performed this is the computational domain. At every point in space within that computational domain are determined The E and H fields (Nieter & Cary, 2004). Must be specified the material of each cell within the computational domain. For example, the material is either free-space (air), dielectric, or metal. As long as the permittivity, permeability, and conductivity are specified any material can be used. A source is specified once the grid materials and the computational domain are established (Kunz & Luebbers, 1993). The source can be a current on a wire, an impinging plane wave, or an applied electric field, thats depending on the application. Since the E and H fields are determined immediately, at a point or a series of points within the computational domain the output of the simulation is usually the E or H field. The simulation develops the E and H fields forward in time (Doerr, 2014).

2.3 FDTD Formulation

In the FDTD approach, both the space and time are divided into discrete segments. Space is segmented into box-shaped cells, which are small in comparison to the wavelength (Zohrabi, Salakhov, & Kharintsev, 2014). As shown in the figure (3.1) below, on the edges of the box are located the magnetic fields (Hx(i,j,k), Hy(i,j,k) and Hz(i,j,k)) and he electric fields (Ex(i,j,k), Ey(i,j,k) and Ez(i,j,k)) and are positioned on the faces. The Yee cell is Called this orientation of the fields relative to famous Scientist Ye, Keen, divided into small lapses where each step represents the time needed for the field to travel from one cell to the next thats is the basis for FDTD the time. Given an offset in space of the magnetic fields in relation to the electric fields, the values of the field in respect to time are also offset (Sullivan, 2013). By using a leapfrog scheme, the electric and magnetic fields are updated where the electric fields come first, then at each step-in time, the magnetic ones are computed. The result is an FDTD grid or mesh when many FDTD cells are combined together to form a three- dimensional volume. Each FDTD cell with their neighbours will overlap the faces and edges. Therefore, three electric fields for each cell will have begin at a common node associated with it. The electric fields at the other nine edges of the FDTD cell will belong to other adjacent cells. Also, three magnetic fields originating on the faces have each cell will of the cell adjacent to the common node of the electric fields (Chen, Katsurai, & Aoyagi, 1998).

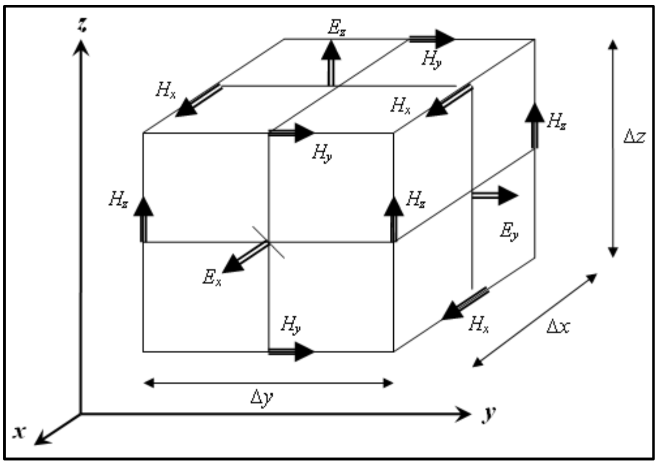


Figure (2.1) : Discretization of the model into cubes and the position of field components on the grid (Rhattoy, Lahmer, & Zatni, 2010).

2.4 Analytical and Numerical Review

2.4.1 Maxwell's Equations

The mathematical relationship of the electromagnetic fields radiated by time-dependent current or charge densities is governed by Maxwell's equations. These can be expressed in differential form as:

$$\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t} \qquad \text{(Faraday's Law)} \qquad (2.1)$$

$$\nabla\times\vec{H} = \frac{\partial\vec{D}}{\partial t} + \vec{J} \qquad \text{(Ampere's law)} \qquad (2.2)$$

coupled with Gauss' law

$$\nabla \cdot B = 0 \qquad \text{(Magnetic field)} \qquad (2.3)$$

$$\nabla \cdot D = \rho \qquad \text{(Electric field)} \qquad (2.4)$$

$\vec{E}$: electric field (volts/meter)

$\vec{D}$: electric flux density (C/m^2)

$\vec{H}$: magnetic field (A/m)

$\vec{B}$: magnetic flux density (Wb/m^2)

$\vec{J}$: electric current density

$\partial\vec{D}/\partial t$: displacement current

ρ : the electric charge density

We also have relations

$$\vec{D} = \varepsilon\vec{E} = \varepsilon_0\varepsilon_r\vec{E} \qquad (2.5)$$

$$\vec{B} = \mu\vec{H} = \mu_0\mu_r\vec{H} \qquad (2.6)$$

where ε_o is the free-space permittivity (8.854×10^{-12} F/m), ε_r is the relative permittivity, and ε is the permittivity (F/m) of the media. Similarly, μ_o is the free-space permeability ($4\pi\times10^{-7}$ H/m), μ_r is the relative permeability, and μ is the permeability (H/m) of the media, in general, μ_r and ε_r are frequency dependent.

Electromagnetic fields are completely described by Maxwell's equations. For sinusoidal time-variation have the form as:

$$\vec{E}(t) = \vec{E_0}\cos(\omega t + \varphi_E) \tag{2.7}$$

$$\vec{H}(t) = \vec{H_0}\cos(\omega t + \varphi_H) \tag{2.8}$$

where ω is the angular frequency (rad), φ_E is the initial phase of Eand φ_H is the initial phase of H. They can also be written in complex phasor representation

$$\vec{E}(t) = Re < \vec{E_0}e^{j(\omega t+\varphi_E)} > \tag{2.9}$$

$$\vec{H}(t) = Re < \vec{H_0}e^{j(\omega t+\varphi_H)} > \tag{2.10}$$

Phasors of $\vec{E}$ and $\vec{H}$ are defined as:

$$\vec{E}(t) = \vec{E_0}e^{j(\omega t+\varphi_E)} \tag{2.11}$$

$$\vec{H}(t) = \vec{H_0}e^{j(\omega t+\varphi_H)} \tag{2.12}$$

The time derivatives can be greatly simplified with the phasor forms as:

$$\frac{\partial \vec{E}}{\partial t} = j\omega\vec{E} \tag{2.13}$$

$$\frac{\partial^2 \vec{E}}{\partial t^2} = -\omega^2\vec{E} \tag{2.14}$$

$$\frac{\partial H}{\partial t} = j\omega\vec{H} \tag{2.15}$$

$$\frac{\partial^2 \vec{H}}{\partial t^2} = -\omega^2\vec{H} \tag{2.16}$$

Maxwell's equations can be written in phasor form as:

$$\nabla\times\vec{E} = -j\mu\omega\vec{H} \tag{2.17}$$

$$\nabla\times\vec{H} = j\varepsilon\omega\vec{E} + \sigma\vec{E} \tag{2.18}$$

$$\nabla\cdot\vec{B} = 0 \tag{2.19}$$

$$\nabla\cdot\vec{D} = \rho \tag{2.20}$$

where σ is the electric conductivity of the surrounding medium (S/m) and $J = \sigma E$ If vacuum is considered as the medium, the equations can be transformed to the propagating in 3D space.

$$\nabla^2\vec{E} + \omega^2\mu\varepsilon\vec{E} = 0 \tag{2.21}$$

$$\nabla^2\vec{H} + \omega^2\mu\varepsilon\vec{H} = 0 \tag{2.22}$$

2.4.2 Maxwell's Equations in One Dimensional Cartsiaian Coordinate

The finite difference time domain (FDTD) method is a full-wave, dynamic, and powerful solution tool for solving Maxwell's equations, introduced by K.S. Yee. To better understand the theory of the method, we will start considering a simple one-dimensional problem. Assume, at this stage, "free space" as propagation medium. In this case, Maxwell's equations can be written as the time-dependent curl equations in a homogenous dielectric medium

$$\frac{\partial\vec{E}}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}\nabla\times\vec{H} \tag{2.23}$$

$$\frac{\partial\vec{H}}{\partial t} = -\frac{1}{\mu}\nabla\times\vec{E} \tag{2.24}$$

where $\vec{E}$ and $\vec{H}$ are vectors in 3D. The constants ε_0 is permittivity and μ_0 permeability in free space and ε_r is the relative permittivity of the material.

for eq (2.23)

$$\frac{1}{\varepsilon_0\varepsilon_r}\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ H_x & H_y & H_z \end{vmatrix} = \frac{\partial\vec{E}}{\partial t}$$

Curl Equations in Cartesian Coordinates, Expanding the equation (3.23) we get:

$$\hat{x}\frac{\partial E_x}{\partial t} + \hat{y}\frac{\partial E_y}{\partial t} + \hat{z}\frac{\partial E_z}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}\left[\hat{x}\left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right) + \hat{y}(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}) + \hat{z}(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y})\right]$$

Equating the vector components, we obtain three equations, one for each vector component, the electric field component becoms

$$\frac{\partial E_x}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}\left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)$$

$$\frac{\partial E_y}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}) \tag{2.25}$$

$$\frac{\partial E_z}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y})$$

Similarly expanding (2.24), We obtain three more equations, that is compomnent of magnatic field as

$$\frac{\partial H_x}{\partial t} = \frac{1}{\mu_0}(\frac{\partial E_y}{\partial z} - \frac{\partial E_z}{\partial y})$$

$$\frac{\partial H_y}{\partial t} = \frac{1}{\mu_0}(\frac{\partial E_z}{\partial x} - \frac{\partial E_x}{\partial z}) \quad (2.26)$$

$$\frac{\partial H_z}{\partial t} = \frac{1}{\mu_0}(\frac{\partial E_x}{\partial y} - \frac{\partial E_y}{\partial x})$$

In one dimensuon finite diffrence method, we consider exciting an Ex component, and assume $E_y = 0$ and E_z =0 and no variation in the x-y plane, i.e $\frac{\partial}{\partial x} = 0 \, . \frac{\partial}{\partial y} = 0$, The equations reduced to

$$\frac{\partial H_x}{\partial t} = \frac{1}{\mu_0}\left(\frac{\partial E_y}{\partial z} - \frac{\partial E_z}{\partial y}\right) = 0$$

$$\frac{\partial H_y}{\partial t} = \frac{1}{\mu_0}\left(\frac{\partial E_z}{\partial x} - \frac{\partial E_x}{\partial z}\right) = -\frac{1}{\mu_0}\frac{\partial E_x}{\partial z} \quad (2.27)$$

$$\frac{\partial H_z}{\partial t} = \frac{1}{\mu_0}\left(\frac{\partial E_x}{\partial y} - \frac{\partial E_y}{\partial x}\right) = 0$$

$$\frac{\partial E_x}{\partial t} = \frac{1}{\varepsilon_0 \varepsilon_r}\left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right) = -\frac{1}{\varepsilon_0 \varepsilon_r}\frac{\partial H_y}{\partial z} \quad (2.28)$$

2.4.3 Description of The FDTD Method for Maxwell's Equations

In this section, we will give a brief description of the FDTD method for the Maxwell equations. A more detailed description may be found in the books about FDTD (Taflove, 1980). The FDTD method is derived by applying central differences on Ampere's and Faraday's laws:

$$\varepsilon\frac{\partial E_x}{\partial t} = \frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} - \sigma E_x$$

$$\varepsilon\frac{\partial E_y}{\partial t} = \frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} - \sigma E_y$$

$$\varepsilon\frac{\partial E_z}{\partial t} = \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} - \sigma E_z \quad (2.29)$$

$$\mu\frac{\partial H_x}{\partial t} = \frac{\partial E_y}{\partial z} - \frac{\partial E_z}{\partial y}$$

$$\mu \frac{\partial H_y}{\partial t} = \frac{\partial E_z}{\partial x} - \frac{\partial E_x}{\partial z}$$

$$\mu \frac{\partial H_z}{\partial t} = \frac{\partial E_x}{\partial y} - \frac{\partial E_y}{\partial x} \qquad (2.30)$$

Figure (2.1) illustration of a standard Cartesian Yee cell used for FDTD, about which electric and magnetic field vector components are distributed. Visualized as a cubic, the difference equations for $\frac{\partial f}{\partial x}$ & $\frac{\partial f}{\partial t}$ are

$$\frac{\partial F^n(i.j.k)}{\partial x} = \frac{\partial F^n(i+1.j.k) - \partial F^n(i-1.j.k)}{\partial x} \qquad (2.31)$$

$$\frac{\partial F^n(i.j.k)}{\partial x} = \frac{F^{n+1/2}(i.j.k) - F^{n-1/2}(i.j.k)}{\partial x} \qquad (2.32)$$

Chapter 3

Simulation of Electromagnetic wave exposure in human tissues

Chapter 3

Simulation of Electromagneticwave Exposure in Human Tissues

3.1 Literature Review

In a simulation, we perform experiments on a model of the real system, rather than the real system itself. We do this because it is faster, cheaper, or safer to perform experiments on the model. While simulations can be performed using physical models -- such as a scale model of an airplane - our focus here is on simulations carried out on a computer. Computer simulations use a mathematical model of the real system. In such a model we use variables to represent key numerical measures of the inputs and outputs of the system, and we use formulas, programming statements, or other means to express mathematical relationships between the inputs and outputs (Jeruchim, Balaban, & Shanmugan, 2006). When the simulation deals with uncertainty, the model will include uncertain variables whose values are not under our control as well as decision variables or parameters that we can control. The uncertain variables are represented by random number generators that return sample values from a representative distribution of possible values for each uncertain element in each replication or experimental trial of the model (Lippman & Rumelt, 1982). A simulation run includes many hundreds or thousands of trials and our simulation model often called a risk model will calculate the impact of the uncertain variables and the decisions we make on outcomes that we care about, such as profit and loss, investment returns, environmental consequences, and the like. As part of our model design, we must choose how numerical values for the uncertain variables will be sampled on each trial (Mun, 2006). Due to the widespread use, in the last years, of personal communications systems, great public concern has arisen about the possible dangerous effects of the electromagnetic radiation on the human health coming, mainly, from mobile telephones and base-station antennas. For this reason, dosimeters studies have to be made to assess the risks in all the possible situations where electromagnetic waves from these sources interact with the surrounding environment, especially with buildings and biological tissues. In order to prevent hazards from those radiations, reference levels have to be observed. Moreover, in some cases, with the exposition of an organ, it can also be necessary to evaluate if basic restrictions which are given in terms of Specific Absorption Rate (SAR) for the frequencies under study are fulfilled. Numerical methods are used for evaluating this last parameter in biological tissues. The finite differences time domain method (FDTD) has been the most used one for SAR and many variavles calculations (Taflove & Hagness, 1995). Mathematical analysis of microwave heating equations in one dimensional skin layer has been discussed (El-dabe, Mohamed, & El-Sayed, 2003; Rattanadecho, 2004). The effect of microwave heating equations on the thermal states of biological tissues and to predict the effects of the thermal physical properties on the transient temperature of tissues and damage function. A study of computation of electromagnetic field inside a tissue at mobile communication has been studied by (Emili, Schiavoni, Francavilla, Roselli, & Sorrentino, 2003), it presents a new approach to calculate the electromagnetic field inside a tissue, composed of electrically excitable cell by means of the FDTD. For the sake of simplicity, the tissue has been represented with spherical cells but the method can be applied to more general cases. The tissue has been discretized with one micrometer step. The theoretical analysis of the biological thermal effect of millimeter waves in layered dielectric-slabs in human body has been studied by (Yan & Wang, 2003), the model is a plane straticulate homogeneous slab of tissue under the irradiance of normal incidence plane wave. It has been discussed by obtaining the electromagnetic field, absorbent power, Specific Absorption rate, temperature field and their distributions in the human trunk model. This research can be very beneficial in widening the idea of clinical thermal technology and thermal medical practices (El-dabe et al., 2003). Analytical formulations in SAR distribution calculations are extremely difficult Computation of Specific Absorption Rate in the human body to base-station antennas using a Hybrid Formulation is found in reference. SAR simulation in wireless communication and safety discussions in the society discussed by (Abd-Alhameed, Excell, & Mangoud, 2005). A multi-layered structure representing simplified model of the human head irradiated by plane wave in the frequency range of 100MHz-300GHz was investigated (Paker & Sevgi, 2000a), general electromagnetic formulation on the absorption properties of the layered head model is given exact analytical expressions are given for the plane wave complex reflection coefficient as a function of frequency at the interference of the stratified structure, results highlight the position of maximum power absorption values and their dependence on frequency and dielectric parameter.

3.2 1D-FDTD Solution to Maxwell's Equations

In a simple one-dimensional case, we will consider the case where only the E_x & H_y components exist consistent with modeling plane wave propagation far away from an antenna. Equations (2.23) and (2.24) becomes:

$$\frac{\partial E_x}{\partial t} = -\frac{1}{\varepsilon_0}\frac{\partial H_y}{\partial z} \tag{3.1}$$

$$\frac{\partial H_y}{\partial t} = -\frac{1}{\mu_0}\frac{\partial E_x}{\partial z} \tag{3.2}$$

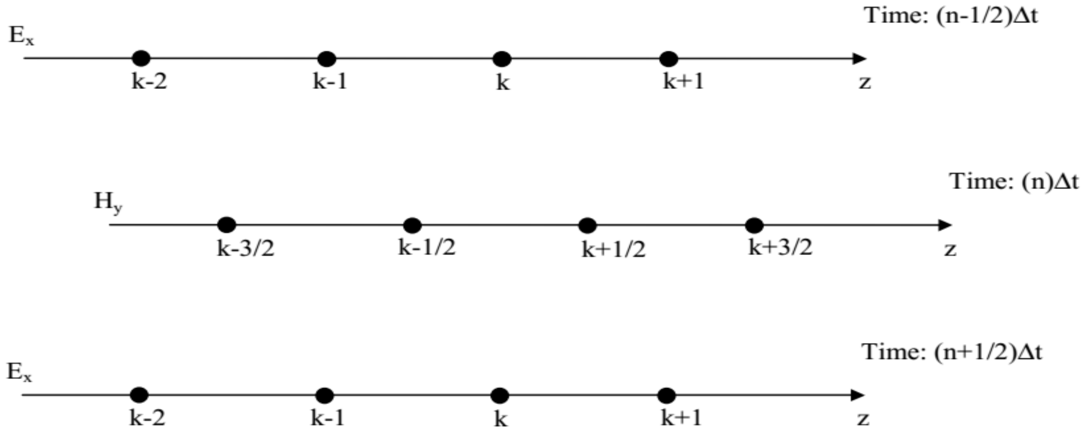
These equations represent a plane wave with the electric field oriented in the x- direction and magnetic field oriented in y-direction and traveling in z-direction. In the FDTD formulation, the central difference approximations for both the temporal and spatial derivatives are obtained at $Z = K\Delta Z$,$t = n\Delta t$, for the first equation (3.1)

$$\frac{E_x^{n+\frac{1}{2}}(k)-E_x^{n-\frac{1}{2}}(k)}{\Delta t} = \frac{1}{\varepsilon_0\varepsilon_r}\frac{H_y^n\left(k+\frac{1}{2}\right)-H_y^n(k-\frac{1}{2})}{\Delta z} \tag{3.3}$$

and equation (3.2):

$$\frac{H_y^{n+1}\left(k+\frac{1}{2}\right)-H_y^{n}\left(k+\frac{1}{2}\right)}{\Delta t} = \frac{1}{\mu_0}\frac{E_x^{n+\frac{1}{2}}(k+1)-E_x^{n+\frac{1}{2}}(k)}{\Delta z} \tag{3.4}$$

In the above equations, n is the time index and k is the spatial index, which indexes. Times $t = n\Delta t$ and positions $Z = K\Delta Z$, or positions $t = n \pm \frac{1}{2}$ and positions $z = \left(K \pm \frac{1}{2}\right)\Delta z$. The time index is written as a superscript, and the spatial index is within brackets. Equations (3.40) and (3.41) can be rearranged as a pair of 'computer update equations', which can be repeatedly updated in loop, to obtain the next time values of $E_x^{n+\frac{1}{2}}(k)$and $H_y^{n+1}\left(k+\frac{1}{2}\right)$, corresponding the $E_x\left(t+\frac{\Delta t}{2}\cdot z\right)$ and $H_y(t+\Delta t. z+\Delta z/2)$. This scheme is known as "leap-frog" algorithm. Practically, it means that to approximate Maxwell's equations in space and time using this algorithm, one should calculate first all H field values, then all E field values, remembering always that E and H are shifted also in space by half of the discretization Δx. Belw figure shows schematically the algorithm.



In equations (3.3) and (3.4) ε_0 & μ_0 differ by several orders of magnitude, E_x and H_y will differ by several orders of magnitude. Numerical error is minimized by making the following change of variables as:

$$\widetilde{E}_x = \sqrt{\frac{\varepsilon_0}{\mu_0}} E_x \tag{3.5}$$

which bring the field quantities to similar levels, Implementing the changing of variables, equations (3.3) and (3.4) becomes

$$\widetilde{E}_x^{\,n+\frac{1}{2}}(K) = \widetilde{E}_x^{\,n-\frac{1}{2}}(k) - \frac{1}{\varepsilon_r\sqrt{\varepsilon_0\mu}}\frac{\Delta t}{\Delta z}\left[H_y^n\left(k+\frac{1}{2}\right) - H_y^n\left(k-\frac{1}{2}\right)\right] \tag{3.6}$$

$$H_y^{n+\frac{1}{2}}\left(k+\frac{1}{2}\right) = H_y^n\left(k+\frac{1}{2}\right) - \frac{1}{\sqrt{\varepsilon_0\mu}}\frac{\Delta t}{\Delta z}\left[\widetilde{E}_x^{\,n+\frac{1}{2}}(K+1) - \widetilde{E}_x^{\,n+\frac{1}{2}}(K)\right] \tag{3.7}$$

3.2.1 Stability and the FDTD Method:

For stability purposes, we need to choose the cell size to allow 10 to 15 points per wavelength. In free space, an electromagnetic wave travels a distance of one cell in time $\Delta t = \frac{\Delta z}{c_0}$, where c_0 is the speed of light in free space. This limits the maximum time step. In the case of a 2-D simulation, we have to allow for the propagation in the diagonal direction, which brings the time requirement to $\Delta t = \frac{\Delta z}{\sqrt{2c_0}}$ · Obviously, three-dimensional simulation requires $\Delta t = \frac{\Delta z}{\sqrt{3c_0}}$ .We will use in all our simulations a time step of $\Delta t = \frac{\Delta z}{2*c_0}$ where C_0 is the velocity of light in free space, which satisfies the requirements in 1-D, 2-D and 3-D for all media. The factor

$$\frac{1}{\sqrt{\varepsilon_0\mu_0}}\Delta t = c_0\frac{\Delta z/2\cdot c_0}{\Delta z} = 0\cdot 5 \quad (3.8)$$

Making use of equation (3.8) in equation (3.6) and (3.7), we obtain the following computer update equations:

$$ex(k) = ex(k) + \frac{0\cdot 5}{\varepsilon_r(k)}\left[h_y(k-1) - h_y(k)\right] \quad (3.9)$$

$$h_y(k) = h_y(k) + 0\cdot 5[ex(k) - ex(k+1)] \quad (3.10)$$

which are used repeatedly in a loop to update the field quantities at every position at all space, as time progresses. Note that the n or n + 1/2 or n -1/2 in the superscripts do not appear. In equation (3.9) the ex on the right side of the equal sign is the previous value at n - 1/2, and the ex on the left side is the new value, n + 1/2, which is being calculated. In case of the spatial index, k+1/2 and k-1/2 are replaced by k and k-1 in order to specify an integer position in an array. It is understood from the derivation, however, that the value stored in $h_y(k)$ is the H value at position k +1/2 (Sullivan, 2013).

3.2.2 Propagation in A Lossy Dielectric Medium

However, there are many media that also have a loss term specified by conductivity. This loss term results in the attenuation of the propagating energy. Once more we will start with the time-dependent Maxwell equation, but we will write them in a more general form, which will allow us to simulate propagation in media

$$\varepsilon\frac{\partial E}{\partial t} = \nabla\times H - J \quad (3.11)$$

$$\frac{\partial H}{\partial t} = -\frac{1}{\mu_0}\nabla\times E \quad (3.12)$$

$\vec{J}$ is the current density which can also be writte $\vec{J} = \sigma\vec{E}$, where σ is the conductivity. Putting this into Eq. (2.29) and dividing through by the dielectric constant we get,

$$\frac{\partial E}{\partial t} = \frac{1}{\varepsilon_0\varepsilon_r}\nabla\times H - \frac{\sigma}{\varepsilon_0\varepsilon_r}E \quad (3.13)$$

$$\frac{\partial H}{\partial t} = -\frac{1}{\mu_0}\nabla\times E \quad (3.14)$$

$\vec{E}$ and $\vec{H}$ are vectors in three dimensions. The constants ε_0 and μ_0 are known as the permittivity and permeability of free space and ε_r is the relative permittivity of the material. In 1-D, we consider (i) exciting an E_x component, and assume $E_y = 0$ and E_z =0 and (ii) no variation in the x-y plane, i.e. The equation (3.13) reduced to

$$\frac{\partial E_x(t)}{\partial t} = \frac{1}{\varepsilon_0 \varepsilon_r} \frac{\partial H_y(t)}{\partial z} - \frac{\sigma}{\varepsilon_0 \varepsilon_r} E_x(t) \tag{3.15}$$

The FDTD formulation, the central difference approximations for both the temporal and spatial derivatives are obtained at $Z = K\Delta Z$. $t = n\Delta t$ for the equation:

$$\frac{E_x^{n+\frac{1}{2}}(K) - E_x^{n-\frac{1}{2}}(K)}{\Delta t} = \frac{1}{\varepsilon_0 \varepsilon_r} \frac{H_y^n\left(k+\frac{1}{2}\right) - H_y^n\left(k-\frac{1}{2}\right)}{\Delta z} - \frac{\sigma}{\varepsilon_0 \varepsilon_r} \frac{E_x^{n+\frac{1}{2}}(K) - E_x^{n-\frac{1}{2}}(K)}{2} \tag{3.16}$$

In similarly equation (3.14) becomes

$$\frac{H_y^n\left(k+\frac{1}{2}\right) - H_y^n\left(k+\frac{1}{2}\right)}{\Delta t} = -\frac{1}{\mu_0} \frac{E_x^{n+\frac{1}{2}}(K+1) - E_x^{n+\frac{1}{2}}(K)}{\Delta t} \tag{3.17}$$

In the equations, above n is the time index and k is the spatial index, which indexes times $t = n\Delta t$ and positions $Z = K\Delta Z$, or positions $t = \left(n \pm \frac{1}{2}\right)\Delta t$ and positions. The time index is written as a superscript, and the spatial index is$Z = \left(k \pm \frac{1}{2}\right)\Delta Z$ within brackets. Equations (3.40) and (3.41) can be rearranged as a pair of 'computer update equations', which can be repeatedly updated in loop, to obtain the next time values of

$$\widetilde{E}_x = \sqrt{\frac{\varepsilon_0}{\mu_0}} E_x \tag{3.18}$$

$$\widetilde{E}_x^{n+\frac{1}{2}}(K) = \frac{1 - \frac{\Delta t \cdot \sigma}{2\varepsilon_0 \varepsilon_r}}{1 + \frac{\Delta t \sigma}{2\varepsilon_0 \varepsilon_r}} \widetilde{E}_x^{n-\frac{1}{2}}(K) - \frac{1/2}{\varepsilon_r\left(1 + \frac{\Delta t \cdot \sigma}{2\varepsilon_0 \varepsilon_r}\right)} \left[H_y^n\left(k+\frac{1}{2}\right) - H_y^n\left(k-\frac{1}{2}\right)\right] \tag{3.19}$$

$$H_y^{n+1}\left(k+\frac{1}{2}\right) = H_y^n\left(k+\frac{1}{2}\right) - \frac{1}{\sqrt{\varepsilon_0 \mu}} \frac{\Delta t}{\Delta z} \left[E_x^{n+\frac{1}{2}}(K+1) - E_x^{n-\frac{1}{2}}(K)\right] \tag{3.20}$$

$E_x^{n+\frac{1}{2}}(K+1)$ and $H_y^{n+1}\left(k+\frac{1}{2}\right)$, crossponding, $E_x\left(t+\frac{\Delta t}{2}.z\right)$ & $H_y\left(t+\Delta t.z+\frac{\Delta z}{2}\right)$.

In equations ε_0 and μ_0 differ by several orders of magnitude, E_x and H_y will differ by several orders of magnitude. Numerical error is minimized by making the following change of variables asfrom these we can get the computer equations and simulates a sinusoidal wave hitting a lossy medium that has a dielectric constant and conductivity according the frequency which considered. Note that the n or (n + 1/2) or (n–1/2) in the superscripts do not appear. In equation (3.19), the Ex on the right side of the equal sign is the previous value at n –1/2, and the ex on the left side is the new value, n + 1/2, which is being calculated. In case of the spatial index, k+1/2 and k-1/2 are replaced by k and k-1 in order to specify an integer position in an array. It is understood from the derivation, however, that the value stored in $h_y(k)$ is the H value at position k + 1/2. To calculate H_y (k + 1/2), for instance, the neighboring values of Ex at k and k + 1 are needed. Similarly, to calculate E_x (k + 1), the value of H_y at k + 1/2 and k + 1 are needed(Kunz & Luebbers, 1993; Sullivan, 2013). The most important points in FDTD calculations are the stability and numerical dispersion (El Wasife, 2011; Nikolic, Dimitrijevic, Aleksic, & Raicevic, 2016; Rouf & Erni, 2016).

3.3 Dielectric Properties of Biological Tissues

The dielectric properties of tissues have been characterized experimentally in the frequency range 10 Hz to 20 GHz (S. Gabriel, Lau, & Gabriel, 1996; Jacques, 2013). These reported data is used for the safety assessments of electromagnetic wave exposure (Hirata & Fujiwara, 2009). Almost all the measurements were performed by in vivo experiments using a nondestructive probe. The results of these measurements represent the ideal condition of the biological tissues, because they include the effects of basal metabolism and blood flow, which are neglected in excited tissue for in vitro measurements. However, the depth of the measured tissues is a practical concern for in vivo measurements demonstrated a quantitative approach for determining the depth of electromagnetic wave penetration in the skin for measurement probes. Unfortunately, the depths of the wave penetration were not reported for the most widely used skin dielectric properties as provided (Lahtinen, Nuutinen, & Alanen, 1997; Sasaki, Wake, & Watanabe, 2014). On the other hand, several studies have estimated the dielectric properties of skin layers and the surrounding tissues using multilayer plane models (Alanen, Lahtinen, & Nuutinen, 1998; Alekseev & Ziskin, 2007). Our attention was focused on the dielectric properties of the skin layers over gigahertz frequencies, in the microwave to millimeter wave (MMW) band. This is because the total energy absorption by electromagnetic wave exposure over the body surface was concentrated around the gigahertz frequency in the microwave region (Dimbylow, Hirata, & Nagaoka, 2008; Hirata, Asano, & Fujiwara, 2007).

Furthermore, international safety guidelines (Guideline, 1998) use the incident power density of millimeter waves (MMWs) as a basic restriction because temperature elevation over the body surface is a considerable health concern (Elder & Cahill, 1984; Gandhi & Riazi, 1986).

3.4 Human Body Issue

3.4.1 Blood

Blood is red fluid is made up of solids and liquid with proteins and numerous cells suspended in it. The solid part of blood contains red blood cells, white blood cells, and platelets. The liquid part, called plasma, is made of water, salts, and proteins which help blood to clot, transport substances through the blood, and perform other functions. Blood plasma also contains glucose and other dissolved nutrients. Over half of blood is plasma providing the body with nutrition, oxygen, and waste removal. Mostly adult human has about 5 liters of blood (Meena et al., 2015).

3.4.2 Liver Tissue

Weighing in at around (1.2-1.5) kg, considered the largest gland in the human body. It's located in the right part under the diaphragm in the abdominal cavity area. The liver has many functions, the main function is to filter the blood coming from the digestive tract, before passing it to the rest of the body and other functions related to metabolism, immunity, digestion and the storage of nutrients within the body. These functions make the liver a vital organ without which the tissues of the body would quickly die from lack of energy and nutrients. The liver is characterised by its high capacity for regeneration of damaged cells (Sherlock & Dooley, 2008).

3.4.3 Kidney Tissue

The kidneys are a pair of organs located in the back of the abdomen. It's shape like a bean with the convex side of each organ located laterally and the concave side medial about the size of a fist. The functions of kidneys are the waste filtering and disposal system of the body where all the blood in our bodies passes through the kidneys several times a day. Besides thats it removes wastes, control the body's fluid balance, and regulate the balance of electrolytes. Human can live with only one functioning kidney; our kidneys are vital organs. The loss of both kidneys would lead to a rapid accumulation of wastes and death within a few days' time (Tryggvason & Wartiovaara, 2005).

3.4.4 Thyroid Tissue

The thyroid gland is one of the most important glands in the human body. it's a butterfly-shaped organ located in the base of the neck. which primarily influence the metabolic rate and protein synthesis which body uses it to produce the energy and regulate vital body functions. A deficiency or increase in thyroid production of T_3 and T_4 hormones can cause diseases in the body, and the thyroid gland releases its hormones directly into the bloodstream, in response to the organized hormone, called the pituitary gland, called thyroid hormone (TSH). Its size about 2-inches long and lies in front of the throat below the prominence of thyroid cartilage sometimes called Adam's apple (Shagam, 2001).

3.5 Theory and Model

In this work, we consider the effects of electromagnetic waves produced from mobilephone base station, a planar one-layer body model has been chosen blood, liver, kidney and thyroid tissue as shown in figure (3.1). It assumed that a plane electromagnetic wave is incident vertically upon the plane-layered slabs of medium in Z direction, which electric field is in X-direction. The model consists of one layer having dielectric properties.

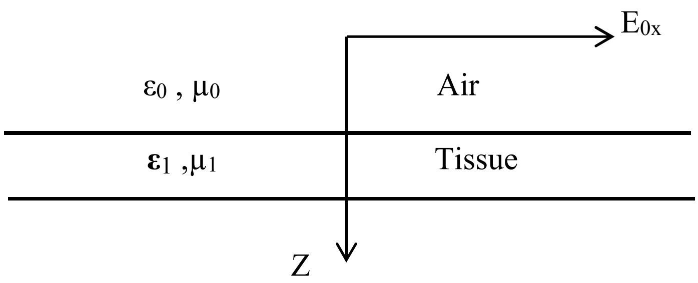


Figure (3.1): Model of layered dielectric slab.

3.5.1 Power Flow of EM Waves

The time-dependent power flow density of the EM wave is given by the instantaneous Poynting vector

$$\vec{P} = \vec{E}(t)\times\vec{H}(t) \tag{3.21}$$

The time-average power flow density for time-varying fields is given by:

$$\langle\vec{P}(t)\rangle = \frac{1}{T}\int_0^T \vec{E}(t)\times\vec{H}(t)\,dt \qquad (3.22)$$

where T is the time period of the Electromagnetic wave.

3.5.2 Calculation Specific Absorption Rate

Specific Absorption Rate stands for (SAR), is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency (RF). The SAR is determined at the highest certified power level in laboratory conditions. However, the actual SAR level of the phone while operating can be well below this value. This is because the phone is designed to use the minimum power required to reach the network. Therefore, the closer you are to a base station, the more likely it is that the actual SAR level will be higher (Paker & Sevgi, 2000b; Umashankar & Taflove, 1982). The Specific Absorption Rate (SAR) is defined as the power dissipation rate normalized by material density. It can be shown that:

$$\text{SAR}=\frac{1}{2*\rho}\vec{J}\cdot\vec{E} = \frac{\sigma}{2*\rho}|E|^2 \qquad (3.23)$$

The SAR distribution within the body is highly in homogeneous, Tissues dielectric properties change with radio frequency. Many studies have been conducted to determine the relationship between dielectric properties and frequency for different types of biological tissues (S. Gabriel et al., 1996; Jacques, 2013). Changing the frequency and running the program, the dielectric properties has been calculated. According to the assumption in research that the layer, represents blood, the conductivity, relative permittivity, wavelength and penetration depth have been evaluated for blood layer.

3.6 Results& Discussion

In simulation study, supposed theoretical model in one dimensional finite difference model for predicting electric and magnetic fields in human life tissues such as blood, liver, kidney and thyroid tissue which undergoing microwave heating. For cell phone radiation , the simulated radiation source is a continuous waveform of 900MHz and 1800MHz, The values of electrical parameters, relative permittivity and electric conductivity for this frequency, are brief in table (3.1) which adopted from (C. Gabriel, Peyman, & Grant, 2009).

Table (3.1): Dielectric properties for blood, thyroid, liver and kidney tissue with Frequency = 900 MHz and 1800 MHz.

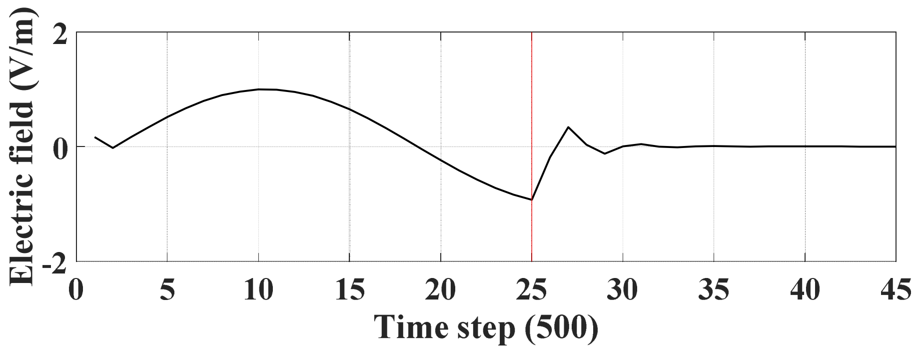
Tissue name	Frequency [MHz]	Density ρ[kg/m^3]	Relative permittivity	Conductivity [S/m]
Air	900&1800	1.299	1	0
Blood Tissue	900	1060	61.36	1.5379
	1800	1060	59.372	2.0435
Thyroid Tissue	900	1100	59.684	1.0385
	1800	1100	58.142	1.501
Liver Tissue	900	1082	46.833	.85497
	1800	1082	44.211	1.2891
Kidney Tissue	900	1064	58.675	1.3921
	1800	1064	54.426	1.9495

Changing the frequency and running the program, the dielectric properties has been calculated. According to the assumption in research. The layer represents the conductivity, relative permittivity, wavelength and penetration depth have.

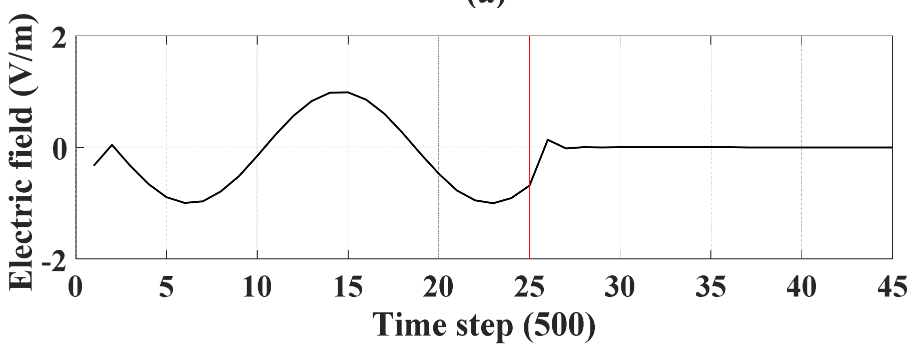
An electromagnetic pulse is radiated from a source located in free space. The source waveform is a sinusoidal shaped pulse, where implementation by Matlab as directional dipole model. This wave travelling in free space and strikes human tissue. When the wave strikes the interface, a fraction of the incoming wave is reflected, and a fraction is transmitted into the tissue layer. The amplitude of the reflected and transmitted waves, relative to the incident wave, is described by the reflection coefficient and the transmission coefficient, which relate the amplitudes of the E field waves. The fields Ez, Hz, Power density and SAR are simulated along the line X =Y = 0, i.e. propagation along the z axis during free space and the tissue layer (blood, Thyroid, liver and kidney).

For Electric field

Figure (3.2, 3.3, 3.4, 3.5) illustrated simulation the electric signal distribution at layer obtained inside the tissue model in XY plane, at 500 iterations in blood, thyroid, liver and kidney tissue at: (a) f= 900 MHZ, (b) f=1800 MHZ respectively, for distance 25 cm. This graph shows, the rang from 0 to 25 it represents free space, the graph show that an electromagnetic pulse is radiated from a source located in free space, but when the pulse strikes the tissue interface the wave propagates more slowly until decays after that represent tissue, and the pulse length is shorter, the electric field is high value when strike the tissue at 900MHz compared with frequency 1800MHz in all tissue. It varies from tissue to tissue in the body both because the electric field changes with position and because the conductivity is different for different types of tissue.



(a)



(b)

Figure (3.2): Simulation of Electric field at 500 iterations in blood human tissue for distance 25 cm at:(a) f= 900 MHZ, (b) f=1800 MHZ.

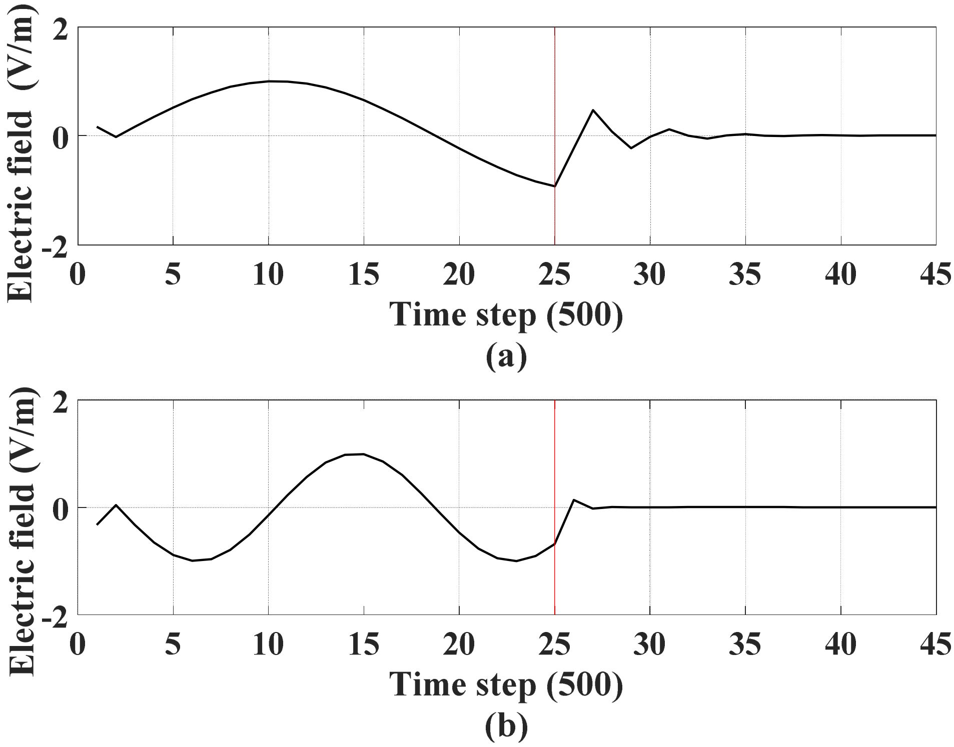


Figure (3.3): Simulation of Electric field at 500 iteration Thyroid human tissue for distance 25cm at:(a) f= 900 MHZ, (b) f=1800 MHZ.

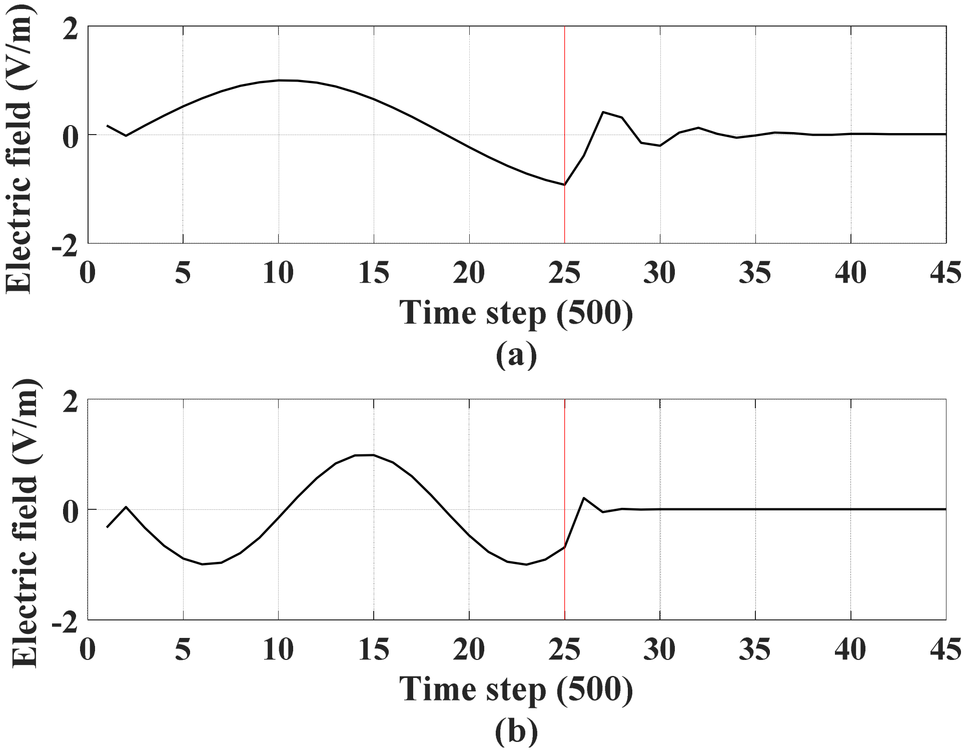


Figure (3.4): Simulation of Electric field at 500 iterations in Liver human tissue for distance 25cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ.

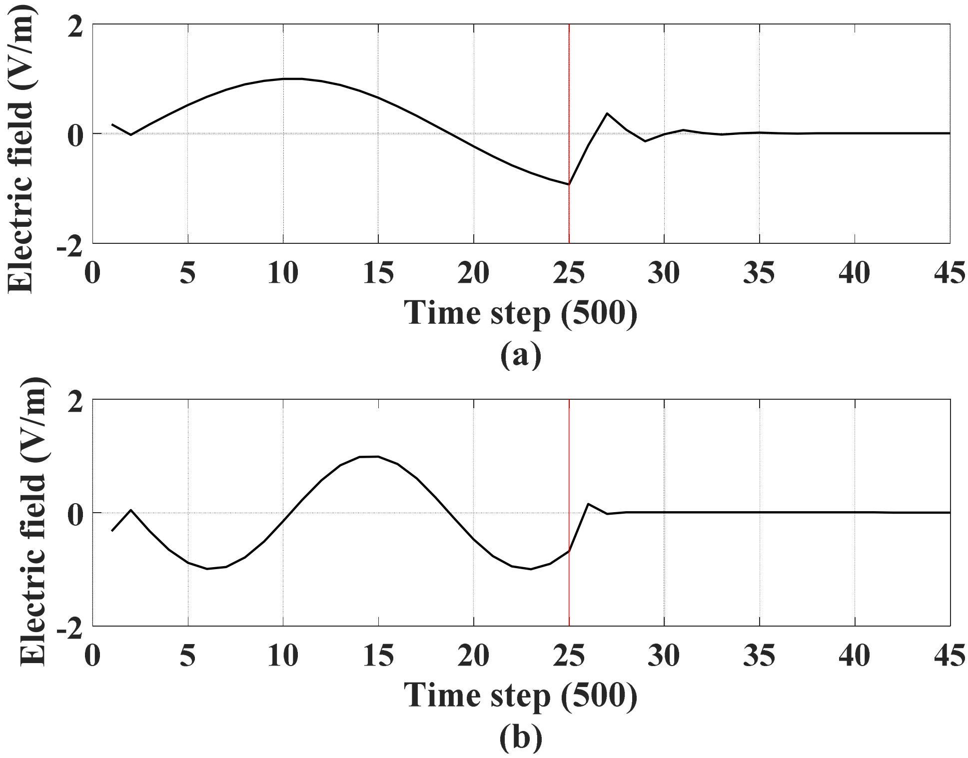


Figure (3.5): Simulation of Electric field at 500 iterations in Kidney human tissue for distance 25cm at:(a) f= 900 MHZ, (b) f=1800 MHZ.

For Magnetic field

Simulation of magnetic field in blood, thyroid, liver and kidney tissue for distance 30 cm at two different frequencies is shown in Figure (3.6, 3.7, 3.8, 3.9) respectively, for distance 30 cm at this graph shows, the rang from 0 to 30 it represents free space, the graph show relation between Magnetic in y-dimension and time step where signal amplitude is decrease when it strikes the human tissue reached zero. furthermore, in thyroid, liver and kidney tissue the maximum peak of magnetic field is at 900MHz as evident, the amplitude of the magnetic field is more than electric field amplitude and decrease fast by much time steps through the tissue, where the blood tissue decaying the fastest from another tissue.

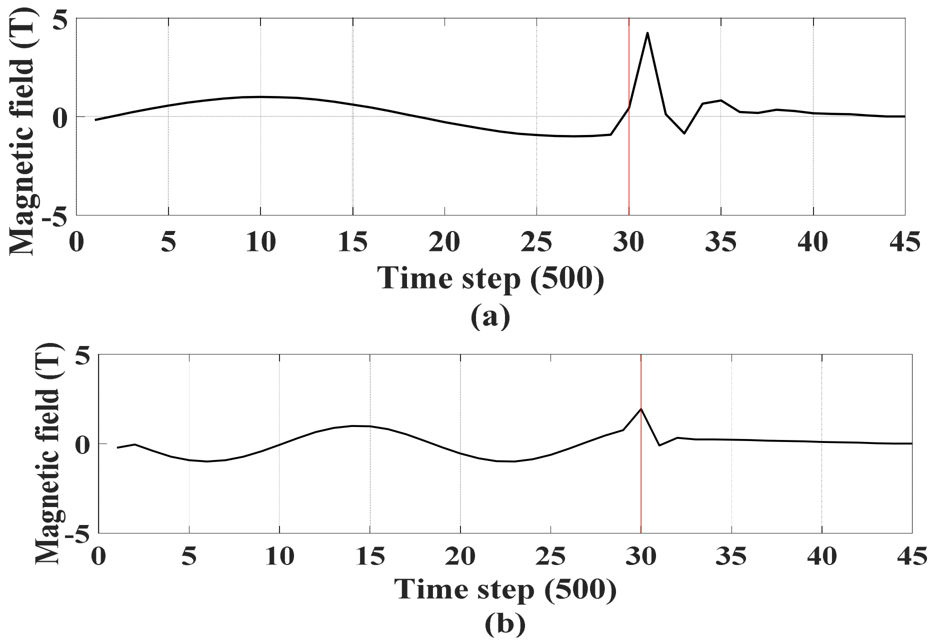


Figure (3.6): Simulation of magnetic field at 500 iterations in blood human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f=1800 MHZ**.**

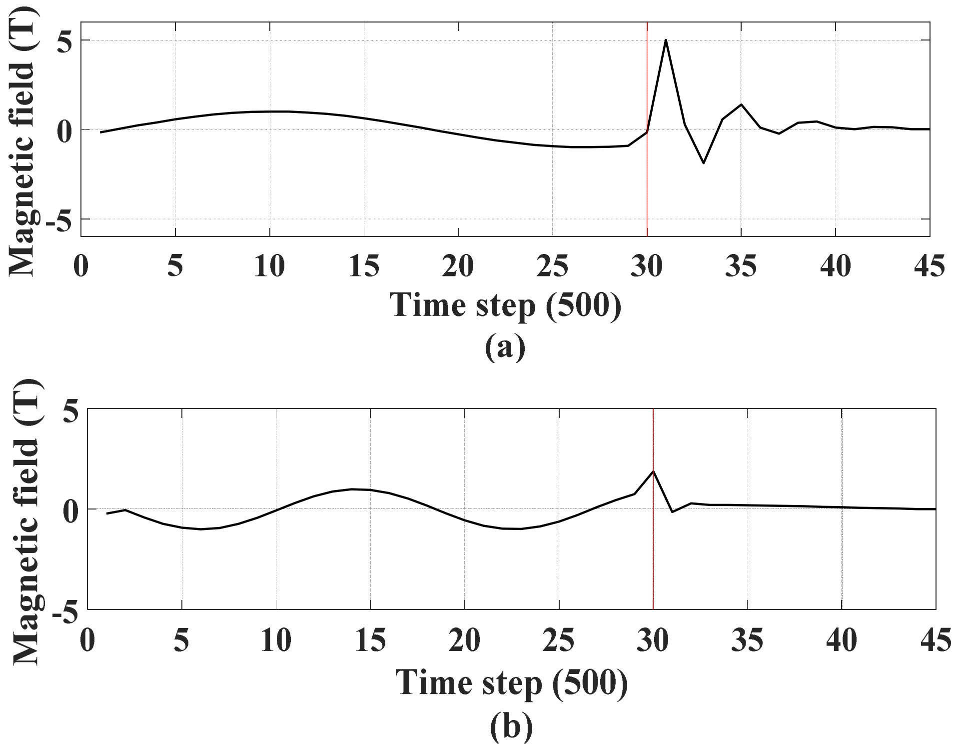
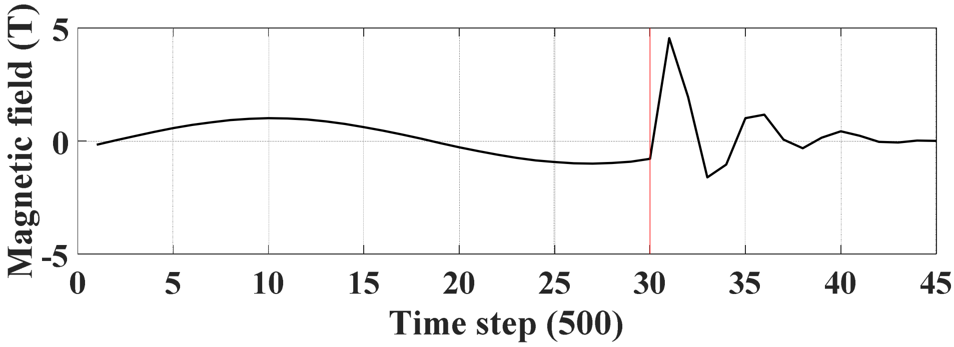
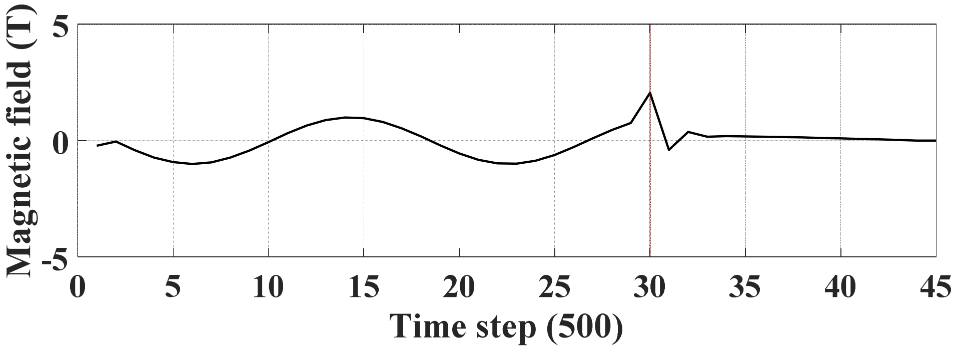


Figure (3.7): Simulation of magnetic field at 500 iterations in Thyroid human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ**.**

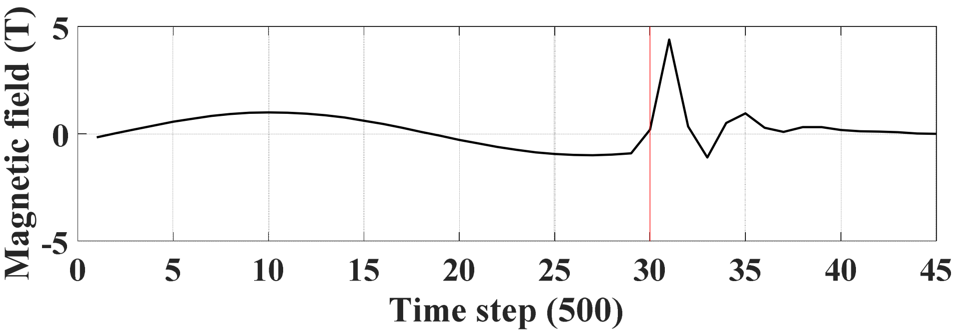


(a)

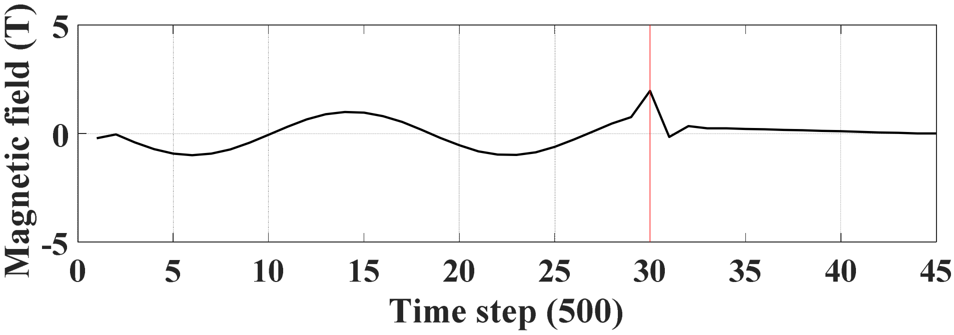


(b)

Figure (3.8): Simulation of magnetic field at 500 iterations in Liver human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ.



(a)



(b)

Figure (3.9): Simulation of magnetic field at 500 iterations in Kidney human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f=1800 MHZ

For Power density

Power density (or volume power density or volume specific power) is the amount of power (time rate of energy transfer) per unit volume, Unit of measurement is W/m^3. Its directly proportional according the density of the tissue as in equation. Figure (3.10, 3.11, 3.12, 3.13) show that relation between power density vs time steps are obtained, power density is zero in free space and increases to maximum at tissue and decrease finally to reached zero. the Relative permittivity of dielectric properties according different frequencies for blood, liver, kidney and thyroid tissues. There is a clear difference between peak value in tissues, where the liver tissue has the highest value after that the kidney then thyroid, the blood is the lowest value, power density is high value when strike the blood tissue compared with frequency 1800MHz.

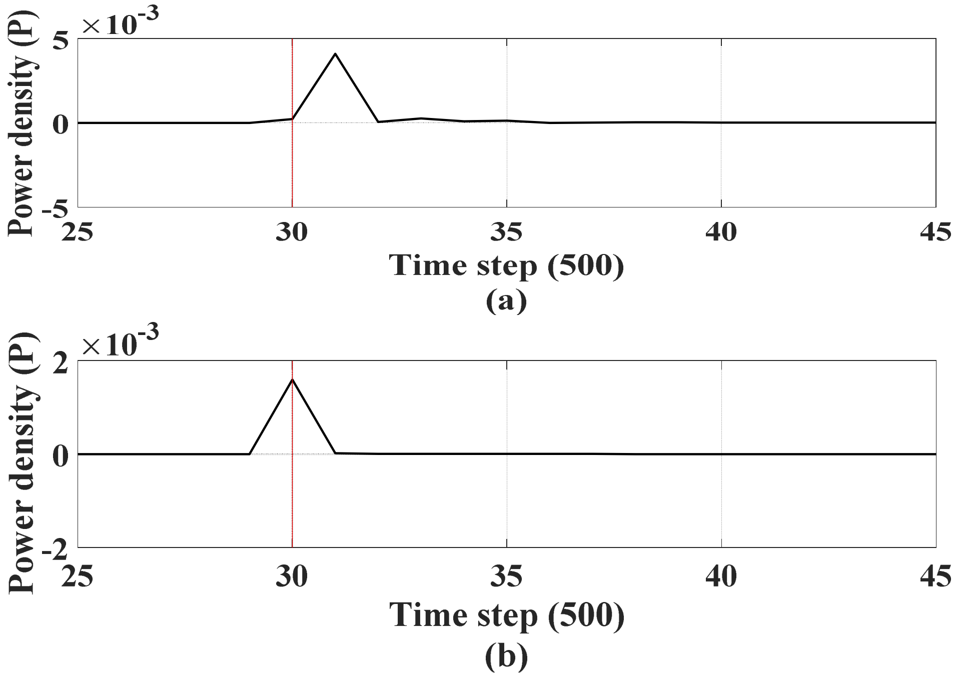
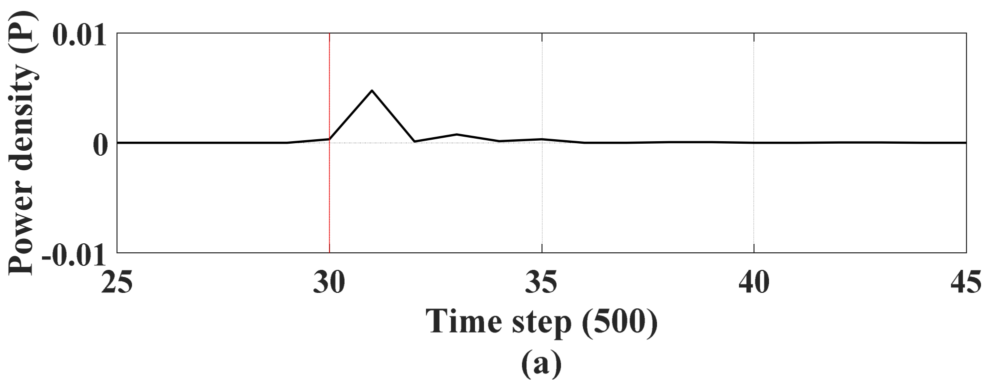
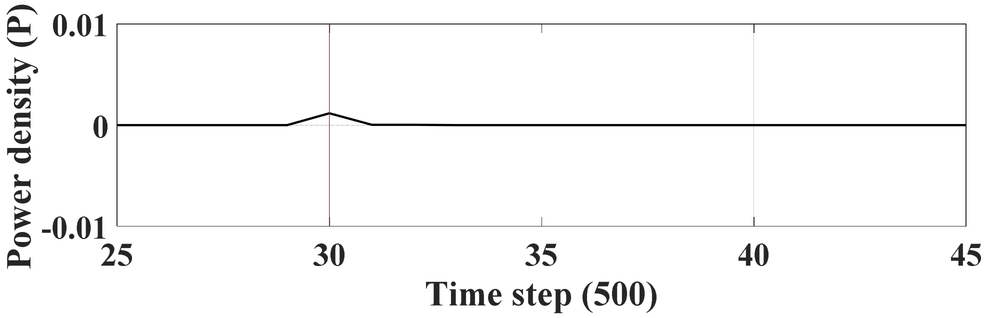


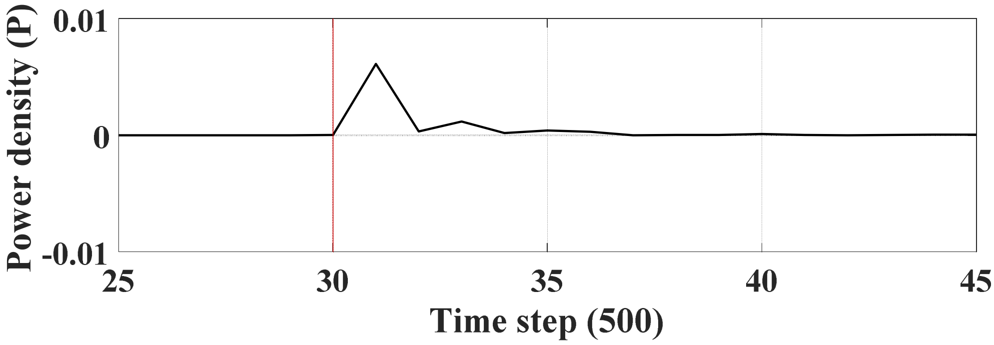
Figure (3.10): Simulation of power density at 500 iterations in blood human tissue for distance 30 cm at: (a) f= 900 MHZ, (b) f=1800 MHZ.



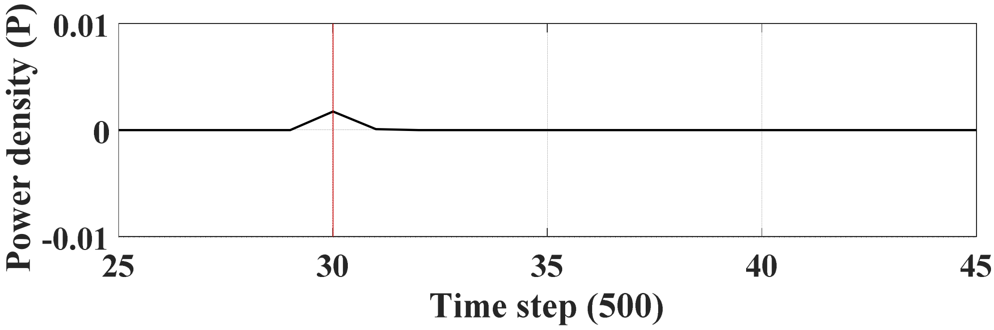


(b)

Figure (3.11): Simulation of power density at 500 iterations in Thyroid human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ.

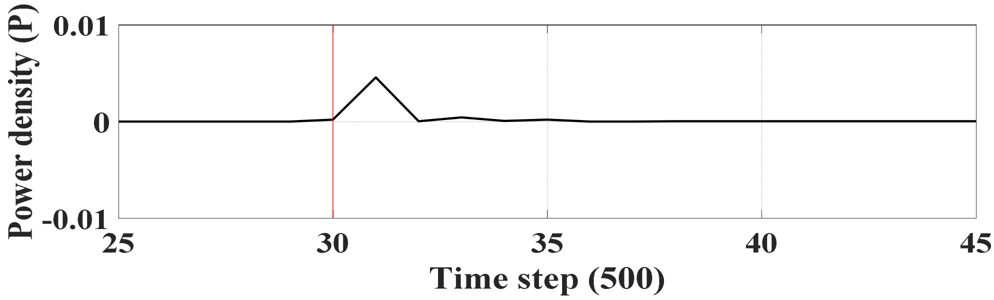


(a)

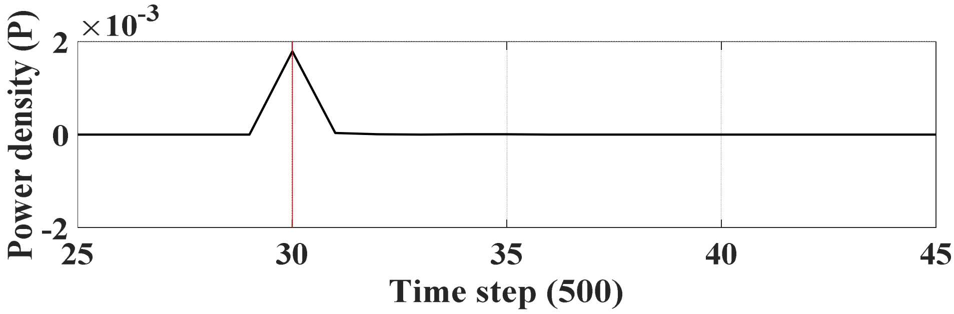


(b)

Figure (3.12): Simulation of power density at 500 iterations in Liver human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ.



(a)



(b)

Figure (3.13): simulation power density at 500 iterations in Kidney human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f=1800 MHZ.

For Specific Absorption Rate (SAR)

The power absorbed per unit mass is given by the following expression

$$\text{SAR} = \frac{\sigma E^2}{2\rho},$$

Where σ is electrical conductivity of tissue and ρ is the mass density. SAR is the specific energyAbsorption Rate and is measured in watts per kilogram. It varies from point to point in the body both because the electric field changes with position and because the conductivity is different for different types of tissue. In most cases, SAR is directly proportional to the distance between the antenna and the Tissue. By using liver and kidney human tissue with different dielectric properties by different frequencies. Figure (3.14, 3.15, 3.16, 3.17) show the simulation result of Specific Absorption Rate at 500 iterations in human tissue for frequencies 900 MHZ and 1800 MHZ respectively, the relation between SAR and time step show that it increases from zero at free space, and decrease until back to zero. It is clear that wave distortion occurred in curves using 900 MHz while the wave is decayed at frequency 1800 MHz. Which have higher peak values in blood, that is normal because the nature of blood is liquid.

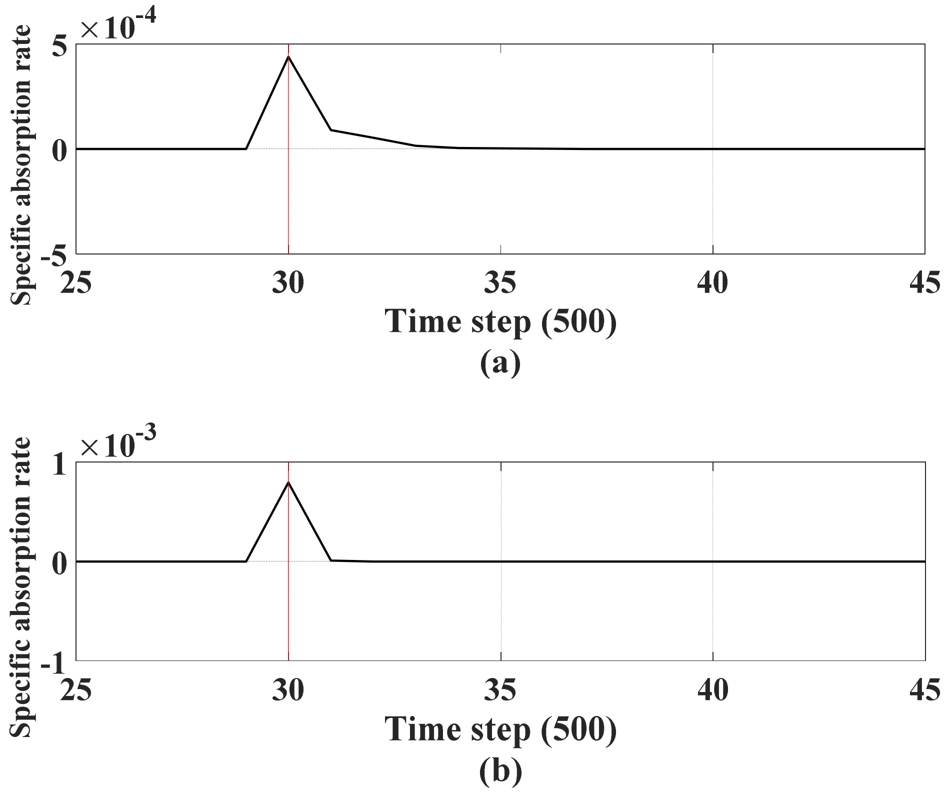


Figure (3.14): Simulation of Specific Absorption Rate (SAR) at 500 iterations in blood human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f=1800 MHZ.

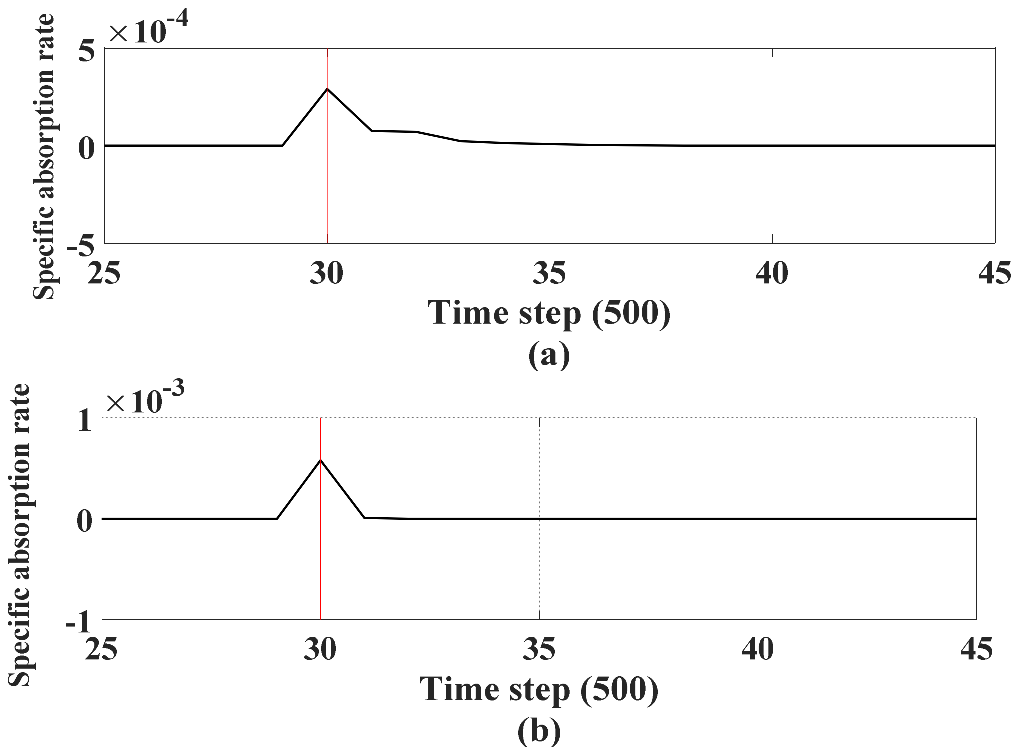


Figure (3.15): Simulation of Specific Absorption Rate (SAR) at 500 iterations in Thyroid human tissue for distance 30 cm at: (a) f= 900 MHZ, (b) f=1800 MHZ.

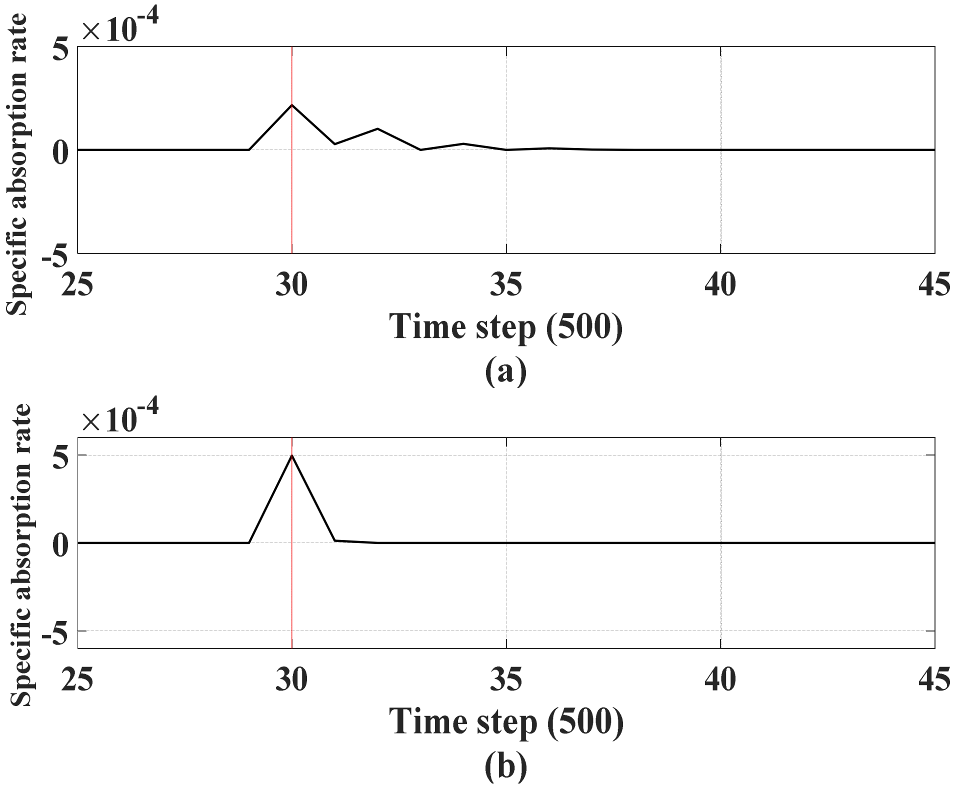


Figure (3.16): Simulation of Specific Absorption Rate (SAR) at 500 iterations in liver human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f= 1800 MHZ.

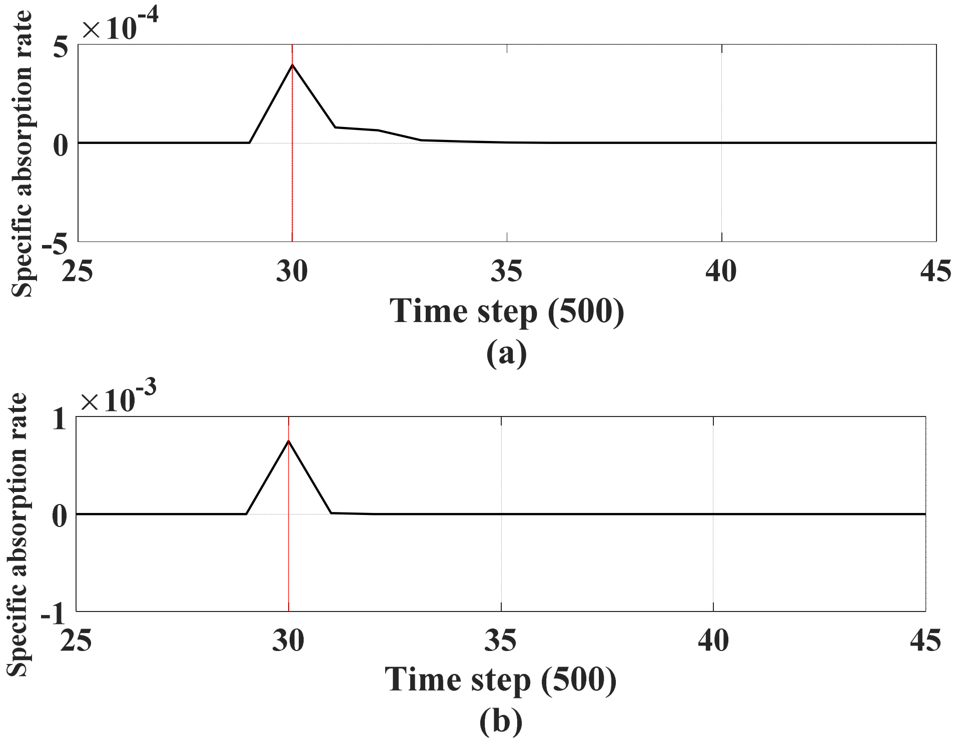


Figure (3.17): Simulation of Specific Absorption Rate (SAR) at 500 iterations in Kidney human tissue for distance 30 cm at:(a) f= 900 MHZ, (b) f=1800.

Using Origin pro software program

Figure (3.18) shows a frequency versus conductivity in different human tissue as blood, liver, kidney and thyroids tissue, Electrical conductivity, a measure of a material's ability to conduct an electric current. The conductivity is increase by increasing frequency in low frequency but almost constant at high frequency. the Relation of Loss tangent with different frequencies for blood, liver, kidney and thyroid tissues is evident in Fig (3.19). Dielectric loss quantifies a dielectric material's inherent dissipation of electromagnetic energy (e.g. heat) It can be parameterized in terms of either the loss angle δ or the corresponding loss tangent tan δ. Both refer to the phasor in the complex plane whose real and imaginary parts are the lossy component of an electromagnetic field and its lossless counterpart

as loss tangent can be expressed by the formula

$$\tan\delta = \frac{\sigma}{\omega\varepsilon}$$

so, it decreases by increasing frequency. The blood has more lose tangent than other tissue.

In Figure (3.20) it is clear the penetration depth with different frequencies for so human tissue which supposed in research as blood, liver, kidney and thyroid tissues. Penetration depth is a measure of how deep light or any electromagnetic radiation can penetrate into a material. It is defined as the depth at which the intensity of the radiation inside the material falls about 37% of its original value.

When electromagnetic radiation is incident on the surface of a material, it may be some of the waves are reflected from that surface and there will be a field containing energy transmitted into the material. This electromagnetic field interacts with the atoms and electrons inside the material. Depending on the nature of the material, the electromagnetic field might travel very far into the material, or may die out very quickly. For a given material, penetration depth will generally be a function of frequency. it seems that the natural of tissue is important to affected by exposure to electromagnetic field produced from mobile phone base station.

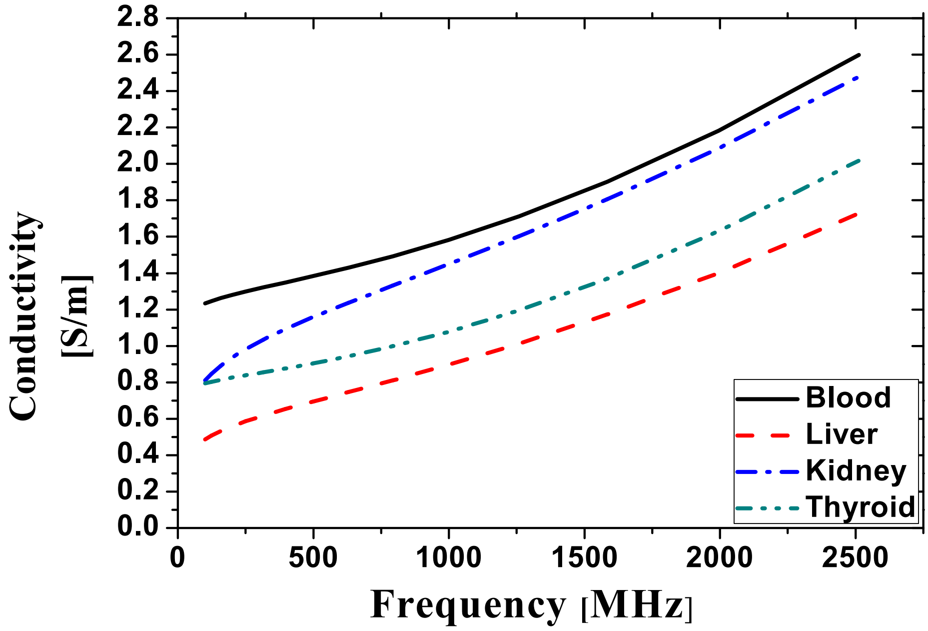


Figure (3.18): Conductivity with different frequencies for blood, liver, kidney and thyroid tissues.

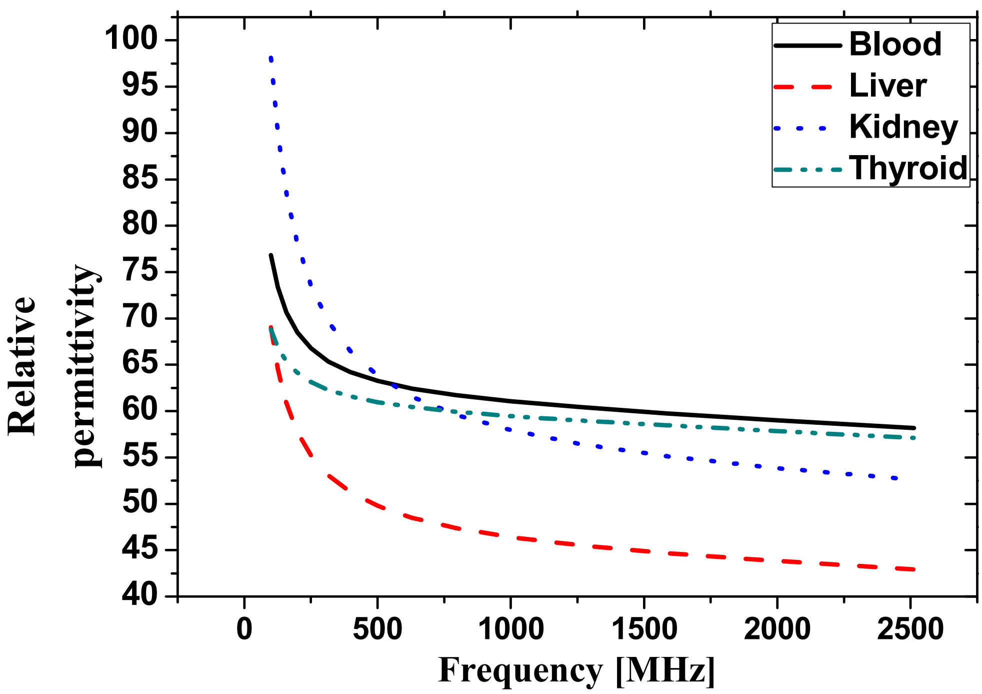


Figure (3.19): Relative permittivity of dielectric properties according different frequencies for blood, liver, kidney and thyroid tissues.

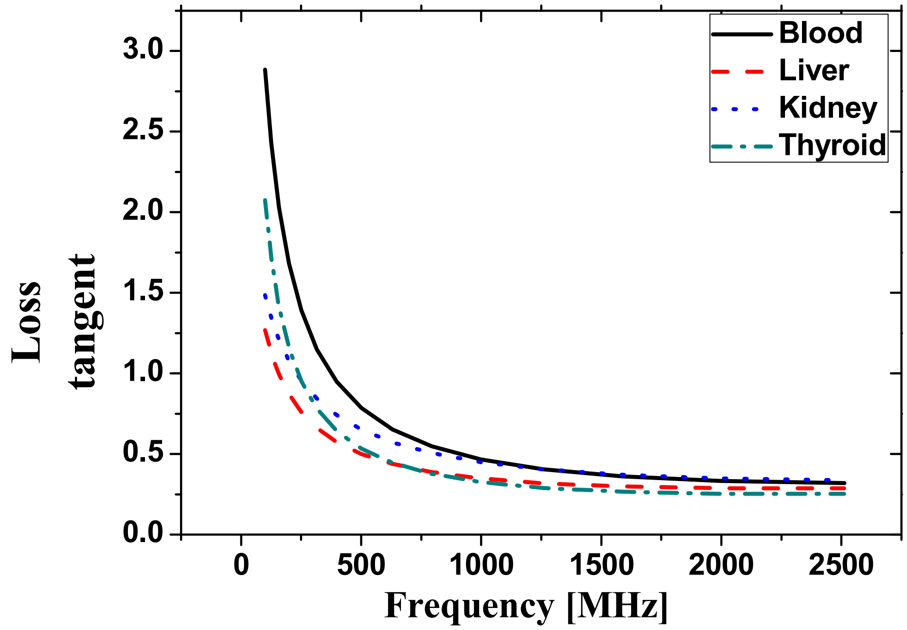


Figure (3.20): Relation of Loss tangent with different frequencies for blood, liver, kidney and thyroid tissues.

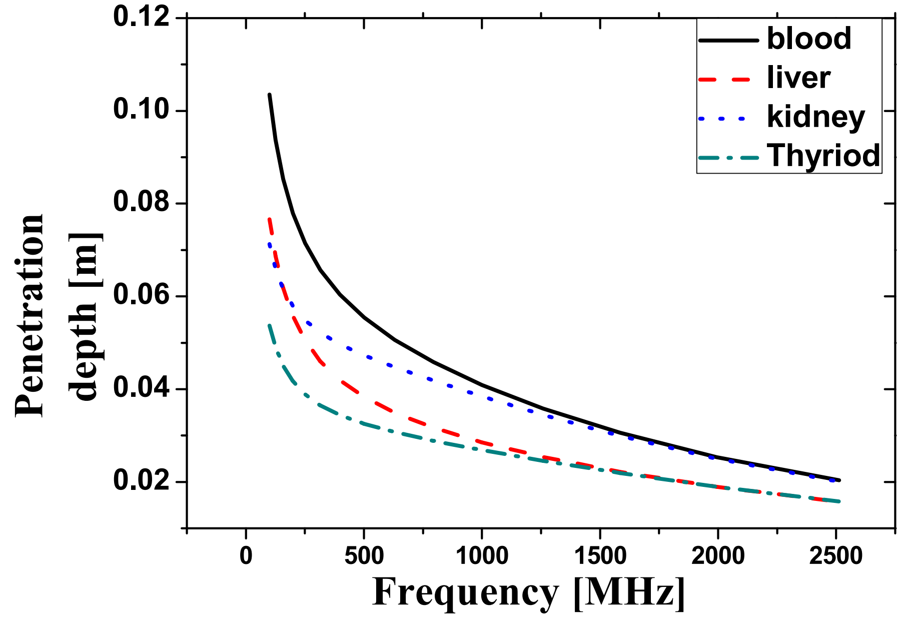


Figure (3.21): Penetration depth with different frequencies for blood, liver, kidney and thyroid tissues.

Chapter4
Experimental Method and Results

Chapter4
Experimental Method and Results

4.1 Introduction

In recent years, use of mobile phone telecommunication has drastically increased the amount of human exposition from the microwaves (MWs) radiation in everyday life. Because it became impossible to imagine a world without mobile communication, a growing concern about the possible health hazards have increased greatly among public, even on those who do not use such phones (Shahbazi-Gahrouei, Karbalae, Moradi, & Baradaran-Ghahfarokhi, 2014). Now, millions of people around the world use form of cell phones that so called mobile phones. The antennas had the task of receiving and sending waves. This lead that installing and using this antenna have become popular in different places including residential areas (Taheri et al., 2016). The waves used in the establishment of connectivity through mobile phone were in the range of the microwaves 900 MHz /1800 MHz. Considering the importance of this issue, in 1996, the World Health Organization (WHO) in collaboration with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) started an international project on the effects of electromagnetic fields for assessing the potential risks of these waves for human health (Bernhardt & Matthes, 1997) with regard to the possible adverse effects of this radiation on biological systems and thus people's health at risk. There has become a great public debate and a large number of scientific conferences and research on the biological risks of the effects of electromagnetic waves on human health (Khurana et al., 2013; Mortazavi, Mortazavi, & Mortazavi, 2016; Röösli, Frei, Mohler, & Hug, 2010). The biologic effects caused by electromagnetism field depend on their physical characteristics frequency, intensity, and the effected tissue (Jelodar, Saravani, & Rezaie, 2013). In lower frequencies, the electromagnetic waves, called non-ionizing waves, do not have enough energy for ionization (Guy, 1987). Electromagnetic radiation may be absorbed by various body organs according to places the mobiles are carried particularly kidneys and liver (Ozguner et al., 2005). Fundamental intensity threshold signal that is emitted by mobile base station may be appropriate to its physiological temperature and biological reactions within the cells. During lingering exposure, the effects can change from stimulant to inhibition, depending on the pulse shape (Achudume, Onibere, & Aina, 2009). Effect of electromagnetic fields on living organisms through previous studies showed the triggering of key biochemical processes in different metabolic pathways also the physicochemical action macrostructure, electrolytic polarization, ion, macrostructure, the dipolar and another factor may also play a role such as biochemical activation, weakening chemical bond, molecular excitation for atoms, hydration change, altered relaxation time of atoms vibration, and altered spin of dipoles (B Kula, 1988). In long term, the waves extremely low frequency are leading to get some biochemical properties and variations in structure of the tissues (Đinđić et al., 2010; Lerchl et al., 2008; Ragy, 2015). In other studies showed exposure to static magnetic field to reduce the metabolic activity of HL-60 cells (Sabo et al., 2002) and showed higher plasma glucose levels because of exposure to electromagnetic pollution in addition may contribute to the misdiagnosis of diabetes (Havas, 2008), many studies reported that there are various activities on the effect of electromagnetic fields (EMFs) on proteins (Ke, Sun, Lu, Fu, & Chiang, 2008; Mousavy et al., 2009). In study Roberts, Michaelson has reported that several hematological variables are sensitive to radio frequency exposure, not only in animals, but also in humans (Roberts, Michaelson, & Lu, 1986). The investigation suggests that microwave exposure may affect the hematological parameters of exposed animals, and calls for further evaluation of specificity and biological significance of these biomarkers of exposure. A different study showed that the results which applied global system mobile like microwave exposure may induce slight, but statistically significant alterations in some hematological and endocrine parameters of male mice within the physiological range (Forgács et al., 2004).For example the effects of electromagnetic fields induced by the Global System for Mobile communications (GSM) mobile phones on the Thyroid Stimulating Hormone (TSH) and thyroid hormones in humans have been evaluated (Mortavazi et al., 2009). During the last 30 years, much experimental evidence of non-thermal effects of microwave radiation on living systems has been published in the peer-reviewed scientific literature. Some vitro studies indicated to another influences (Đinđić et al., 2010) for example increased hemolisation and increased permeability of the erythrocyte membrane, increase in calcium ion influx effects on blood-brain-barrier, (Paulraj & Behari, 2002), reduced efficiency of lymphocyte cytoxicity and micronuclei in human blood lymphocytes and increase of chromosome aberrations (Dabrowski, Stankiewicz, Kubacki, Sobiczewska, & Szmigielski, 2003) thats means the possibility that radio Frequency (RF) radiation may cause changes in protein conformation and hence biological properties. Olive oil was chosen as a treatment because of many of previous studies was used it as a treatment for the effect of radiation protection, as well as being desirable to people as a natural substance. Furthermore, many studies have shown that it is has many benefits to human health for instance it improves the major risk factors for cardiovascular disease, such as the lipoprotein profile, glucose metabolism, blood pressure and antithrombotic profile. In this chapter, we will study the effects of non- ionizing radiation emitted from the base station on the health of children and possible protective role of Olive oil supplementation provided to the target children.

4.2 Subject and Methods

One hundred and twenty of male children (aging 6-12 years) have been subjected for the experimental work. They were divided into three groups as follows

1. The first group served as control.
2. The second group was exposed to electromagnetic field (E.M.F) emitted from the base station radiation.
3. The third group was exposed to E.M.F and given 2.5 ml / day orally Olive oil all over the experimental periods for 5 weeks.

The second and third groups lived nearby mobile phone base station (100-150) m more than 5 years with range of exposed to electromagnetic field with constant power in (1.4–4.7) mw/cm^2, which is used in their country and measured during the experiment using power meter. The range of electric field about (60–130) V/m. The signal was received by the antenna from mobile base station at the area. The mobile system used in Gaza is GSM (Global system for mobile), where its frequency equals 900 MHz. All of the participats filled questionnaire including detailed about health, behavior, and physical conditions. Blood samples were collected to investigate Complete Blood Count (CBC) and some biochemical parameters in all participats. A sample of about (5 ml) of venous blood was obtained for each subject and dividing into EDTA tube (1.0 ml) and vacutainer plain tube (4.0 ml), To allow blood coagulation vacutainer plain tubes were left about 15 min, after that for 20 min the samples were separated it by centrifugation at 3000 r.p.m and for various biochemical assays it was kept it in the refrigerator. Serum glucose was determined according to the method of Trinder (Trinder, 1969). According to the method of Pierro Fossati serum triglyceride concentration determined enzymatically (Pierro Fossati & Prencipe, 1982). Also by following instruction manuals of Randox reagent kit according to Richmond method serum total cholesterol levels was determined (Allain, Poon, Chan, Richmond, & Fu, 1974). According to the biuret reaction as designated by (Armstrong & Carr, 1964) method serum total protein was determined. Serum albumin was determined using RANDOX reagent kits and following their instruction manual according to the method of Doumas et al (Doumas, Hause, Simuncak, & Breitenfeld, 1989). By the following equation, the globulin concentrations were calculated: Concentration of globulins (gm/dl) = Total Protein - Albumin. Determination of Urea is based upon the cleavage of urea with urea's (Berthelot's reactions) according to (Fawcett & Scott, 1960). The kit was purchased from Boehringer Mannheim diagnostics. Using the SPINREACT reagent kits and following their instruction manual described by (Piero Fossati, Prencipe, & Berti, 1980) serum uric acid was determined , without protein precipitation according to (Bartels & Wüthrich, 1994) serum creatinine was determined, Serum aminotransferase (ALT, AST) was determined according to the method of (Reitman & Frankel, 1957), according to the method of (Bessey, Lowky, & Brock, 1946) serum alkaline phosphatase was determined, also Serum bilirubin was determined according to the method of (Sims & Horn, 1958). The level of TSH was measured by ELISA kits from Dia Metra, Italy. Finally, by using 18 automated parameter hematology analyzers, ABX Microns 60 from Horiba ABX, France determination of Hematological parameter was carried out.

4.3 Data Analysis

Collected data were tabulated and statistical analyses were done using descriptive statistic, means, and standard deviation (SD) of the means were calculated utilizing the computer data processing (SPSS, version 12). A probability value (P) of < 0.05 was considered to be statistically significant.

4.4 Results

4.4.1 Hematological parameter Results:

Table (4.1): Primary and secondary blood indices in children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
RBC (x10^{6}cell/mm^3)	5.50±0.12	4.45±0.05	4.56±0.19
%Change		-19.1	-17
P value		< 0.01	< 0.01
Hb (g/dl)	13.67±0.16	11.75±0.12	12.7±0.36
%Change		-14	-7
P value		< 0.05	> 0.05
Hematocrit (%)	42 ±1.8	35.35±.32	38.34±1.51
%Change		-15.83	-8.7
P value		< 0.01	> 0.05
MCV(pi)	76±3.8	79.45±.57	84.07±1.4
%Change		4.5	10.05
P value		> 0.05	< 0.05
MCH (pg)	24.85±0.8	26.4±0.25	27.69±0.64
%Change		6.24	11.87
P value		> 0.05	< 0.05
MCHC(g/dl)	32.5±0.6	32.24±0.25	33.12±0.52
%Change		2.27	1.9
P value		> 0.05	> 0.05

All values expressed as mean ± S.E.
Highly significant differences at P < 0.01
Significant differences at P ≤ 0.05
Non-Significant differences at P> 0.05

Primary and secondary blood indices of the cases exposed to E.M.F with/without the treatment of olive-oil and the control are summarized in table (4.1). For many primary blood indices, the mean red blood cell counts (RBC) were significantly decreased in cases exposed to E.M.F alone compared to controls (4.45±0.05 VS 5.50±0.12×106 cell/ml, % difference= -19.1, $p < 0.01$). However, in cases exposed to E.M.F and treated with Olive oil (4.56±0.19 V.S 5.50±0.12 ×106 cell/ml, % difference= -17, $p < 0.01$).In parallel hemoglobin and hematocrit level were significantly decreased in cases exposed to E.M.F alone compared to controls (11.75±0.12 VS 13.67±0.16 g/dl, %difference= -14.1, $p < 0.01$), and (35.5±0.32 VS 42.67±1.8 g/dl, %difference = -15.83 , p <0.01) respectively. However, E.M.F exposure +Olive oil reduced the decrement rate of hemoglobin and hematocrit to -7.1% and -8.7% respectively compared to controls.

Secondary blood indices inducing MCV, MCH, MCHC were generally increased in cases compared to controls registering % difference of 4.5, 6.24, 2.27 (79.45±0.57pg, 26.40±0.25pg and 33.24±0.25g/dl respectively, p >0.05). However, the treatments of cases with Olive oil increased the elevation rate 10.01%, 12% and 1.91% respectively compared to controls.

4.4.2 White Blood Cells and Platelets Results

Table (4.2) demonstrates table white blood cell count (WBCs), lymphocyte and blood platelets (PLT) in cases and controls. White blood cell count was non-significant, increased in cases exposed to E.M. F alone compared to controls (7.11±0.26 VS 6.7±1.6 $\times 10^3$ cell/ml, **%**difference= 6.12, p >0.05). For differential white blood cell, lymphocyte was also significantly elevated in cases compared to controls (48.79±1.73 VS 40±0.52, %difference= 22, p <0.01). Blood platelets were significantly decreased in cases compared to controls (233.7±8.85VS 270± .6 %difference = -13.5, $p < 0.05$). However, in cases in cases exposed to E.M.F and treated with Olive oil, reduced the decrement rate to -.925% compared to controls (267.5±17.17 VS 270 ± 8.86, %difference= 22, p >0.05).

Table (4.2): White blood cells and platelets blood indices in children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
WBC (x10^{3}cell/mm^3)	6.7±1.6	7.11±0.26	7.25±0.40
%Change		6.12	8.2
P value		> 0.05	> 0.05
Lymphocytes (%)	40±0.52	48.79±1.73	59.66±2.36
%Change		22	49
P value		< 0.01	< 0.01
Platelets(x10^3/mm^3)	270±8.6	233.7±8.85	267.5±17.17
%Change		-13.45	-.925
P value		< 0.05	> 0.05

All values expressed as mean ± S.E.
Highly significant differences at P < 0.01
Significant differences at P ≤ 0.05
Non-Significant differences at P > 0.05

4.4.3 Chemistry Results

The data in table (4.3) summarize the mean value of children blood serum glucose, triglycerides and total cholesterol as affected by E.M.F. Exposure with / without the treated with Olive oil. E.M.F exposure alone in cases increased serum glucose level by 6.75% compared to the control level. However, the treatments of cases by Olive oil reduced the decrement rate to -10.9% compared to the control level. Mean value of serum triglycerides at the end of the experimental period were 100.0, 112.1 and 96.8 mg/dl in the treatments of the control, E.M.F, E.M.F + Olive oil respectively. On the other hand, mean values of serum cholesterol were 130.0,145.3 and 169.4 mg/dl respectively. Protein and non-protein nitrogenous concentration in cases of children's blood serum after exposed to E.M.F and treated with Olive oil were tabulated.

Table (4.3): Glucose, triglycerides and total cholesterol indices in children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
Glucose(mg/dl)	80±3.15	85.4±2.38	71.25±4.19
%change		6.75	-10.9
P value		< 0.05	> 0.05
Triglycerides (mg/dl)	100±4.6	112.1±2.65	96.8±9.89
%change		12.1	-3.2
P value		< 0.05	> 0.05
Cholesterol(mg/dl)	130±2.7	145.3±4.05	169.4±11.96
%change		11.77	30.3
P value		< 0.05	< 0.01

All values expressed as mean ± S.E.
Highly significant differences at P < 0.01
Significant differences at P ≤ 0.05
Non-Significant differences at P > 0.05

In table (4.4), Total protein was decreased exhibiting percentage increase of -13.5%, and albumin value was increased 23% in response to E.M.F exposure alone respectively, compared to control levels. Olive oil was more efficient in lowering the elevated values of total protein and albumin. However, globulin values were decreased in cases exhibiting percentage increase of -43% and 7% respectively compared to the controls.

Table (4.4): Total protein, albumin and Globulin indices in children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
Total protein(mg/dl)	7.25±0.05	6.27±0.18	7.98±0.23
%change		-13.5	10
P value		< 0.01	< 0.05
Albumin(mg/dl)	3.25±0.05	4±0.6	3.7±0.94
%change		23	13.8
P value		< 0.01	< 0.05
Globulin(mg/dl)	4.0±0.02	2.27±0.03	2.7±0.01
%change		-43	7
P value		< 0.01	> 0.05

All values expressed as mean ± S.E.
Highly significant differences at $P < 0.01$
Significant differences at $P \leq 0.05$
Non-Significant differences at $P > 0.05$

In table (4.5) summarizes the mean value of children blood serum, activities of serum alanine transaminase [ALT], Alkaline phosphatase [ALP] and aspartate transaminase [AST] and bilirubin, as affected by E.M.F. exposure with/without treatment with Olive oil. It shows that activities of serum AST, ALT, ALP and Bilirubin increased following E.M.F exposure alone. However, these activities AST and AST were increased 32.5% 41% respectively and activities of ALP and Bilirubin reduced 1.19%, -10% after treatment by Olive oil when compared to cases exposed to E.M.F alone and compared to controls.

Table (4.5): Serum AST, ALT, AlP and Bilirubin activities in children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
AST (U/L)	15.3±0.52	17.4±.48	20.27±0.48
%change		13.7	32.5
P value		< 0.05	< 0.01
ALT (U/L)	17.5±0.55	18.62±.42	24.67±0.5
%change		6.4	41
P value		> 0.05	< 0.01
Alk.Ph (U/L)	44.6±2.2	73.48±1.77	45.13±0.71
%change		64.75	1.1
P value		< 0.01	> 0.05
Bilirubin (mg/dl)	0.7±0.02	0.81±0.02	0.63±0.05
%change		15.4	-10
P value		< 0.01	< 0.05

All values expressed as mean ± S.E.
Highly significant differences at P<0.01
Significant differences at P ≤ 0.05
Non-Significant differences at P> 0.05

Table (4.6) points out the mean serum urea, uric acid and creatinine compared to the controls. In general, E.M.F exposure in cases increased significantly urea, uric acid and creatinine compared to the controls. However, these increments reduced after the treatment by Olive oil. Thyroid-stimulating hormone (TSH) level in cases exposed to E.M.F alone were significantly lower than that in controls (1.78 ±0.8 VS 2.5±0.2**,** % difference = -28.8, p <0.01). However, the activity of TSH was near to the control in cases exposed to E.M.F after treatment by Olive oil (2.46 ±0.16 VS 2.5± 0.2%difference= -1.6 and p > 0.05)**.**

Table (4.6): Effect of electromagnetic field exposure on Urea, Uric acid, Creatinine and simulating thyroid (TSH) on children after exposure of electromagnetic field and the therapeutic action of Olive oil.

Parameter	Control N=30	Electromagnetic field N=50	Electromagnetic field+Olive oil N=40
Urea(mg/dl) **%change** **P value**	24±0.04	27.8±1.01 15.8 < 0.01	24.4±0.42 1.67 > 0.05
Uric acid (mg/dl) **%change** **P value**	3.6±0.28	4.26±0.11 18.3 < 0.01	3.2±0.15 -11.11 < 0.05
Creatinine(mg/dl) **%change** **P value**	0.51±0.01	0.83±0.017 62.7 < 0.01	.66±0.02 29.4 < 0.01
TSH (mU/L) **%change** **P value**	2.5±0.2	1.78±.08 -28.8 < 0.01	2.46±.16 -1.6 > 0.05

All values expressed as mean ± S.E.
Highly significant differences at P<0.01
Significant differences at P ≤ 0.05
Non-Significant differences at P> 0.05

4.5 Discussion

4. 5.1 Primary and Secondary Blood Indices

The results show significantly decrease in primary blood indices including red blood cell count, hemoglobin and hematocrit in the cases exposed to E.M.F compared to the controls and this is acceptable since it is known that the number of red blood cells is proportional to the degree of decrease in hemoglobin concentration (Mousavy et al., 2009; Ramadan, Shalaby, Afifi, & El-Banna, 2011; Yildirim, Yildirim, Zamani, & Okudan, 2009). These results are not really surprising, as previous studies using different models showed comparable data. Mousavy et al isolated human adult hemoglobin (HbA) from RBC of healthy donors, which was then exposed to RF waves in the range between 910 and 940, his results indicated that mobile phone EMFs altered oxygen affinity and tertiary structure of HbA. Furthermore, the decrease of oxygen affinity of HbA corresponded to the EMFs intensity and time of exposure (Mousavy et al., 2009). Regarding secondary blood indices MCV, MCH and MCHC were also found to be higher in the cases exposed to E.M.F compared to controls. Such results are in partially agreement with (Danese, Lippi, Brocco, Montagnana, & Salvagno, 2016; Fatma, Ahkam, Samir, Nomaan, & Sawsan, 2015). Danese et al investigate the influence of radiofrequency (RF) waves emitted by a commercial mobile phone on red blood cells (RBC) in vitro the study population consisted of 16 ostensibly healthy volunteers, he is found the exposure of whole blood to the mobile phone call significantly MCV and MCH, whereas the MCHC remained unchanged. The depletion in the values of the hematological parameters following E.M.F radiation exposure may be attributed to direct damage caused caused by radiation and due to over production of Reactive oxygen species (ROS) by microwave radiation interaction (Abdel-Rassoul et al., 2007). Such as anemia that can arise as a result of long term exposure to non-ionizing radiations from mobile phone base stations. The combined effects of free radicals on the red blood cell membrane and cytoskeleton may contribute to the leak of hemoglobin out of the cells. The hemolysis of the red blood cells reflects the loss of integrity of the cells which can lead to the liberation of intracellular hemoglobin. In addition, radiation was reported to cause oxidation of the sulphydryl groups and induce conformational changes of membrane proteins (Fatma et al., 2015).

4.5.2 Total and Differential White Blood Cells

Total white blood cell count was elevated in the cases compared to controls. Lymphocytes was also higher in the cases. Blood platelets were decreased in cases than controls. The induction of white blood cell count observed in the present study indicates the activation of a defense mechanism and the immune system, which could be a positive response for survival Such results are in partially agreement with (Abdel Aziz, El-Khozondar, Shabat, Elwasife, & Mohamed-Osman, 2010; Hsu et al., 2010) where they investigated the effect of electromagnetic field (EMF) radiated from mobile phones base stations with frequency equals 900 MHz on body weight, blood indices of albino rats after exposing them to the electromagnetic field for 2 weeks and therapeutic action of vitamin C or E against harmful effects induced by electromagnetic field, results show that electromagnetic field exposure caused an increase in the the white blood cell count (WBC) recording as compared to control level. The observed increase in lymphocyte was in agreement with that found by (Abdel Aziz et al., 2010; Fatma et al., 2015).

4.5.3 Chemistry Serum

Our results show an increase in levels of serum glucose in the study cases in response to E.M.F exposure with/without Olive oil that could be attributed to impairing hepatic structure noticed by (Abuo El Naga & Abd Rabou, 2012) who observed decreasing of glycogen in cell after exposed to radiation may be because reduction T3&T4 hormones of the thyroid glands, which reduce access of glucose to the cells. Indirectly may E.M.F exposure, play a specific role in carbohydrate metabolism. E.M.F exposure pulse Olive oil showed a decrease in serum glucose toward control level. In this respect, (Al Jamal & Ibrahim, 2011) studied the protective influence of Olive oil which was attributed to its antioxidant and free radicals scavenging properties, on blood and lipid profile glucose level Olive oil had positive effects in both type2 diabetic and asymptomatic participants. This shows that Olive oil improves the principle functions of the liver which are related to the blood glucose homeostasis and regulation of carbohydrate metabolism (Fatma et al., 2015).

Results also show that total cholesterol and triglycerides levels were increased in response to the exposed cases to E.M.F. The possible explanation of these observed increments may be residing in direct or indirect action of E.M.F exposure on lipid metabolism or lipid peroxidation (Kostoff & Lau, 2013)**.** The significant decreased levels of total protein in the cases treated with E.M.F exposure was agreement with that observed by previous published wrote (Fatma et al., 2015). An increase in amino acids deamination attributed for a decrease of total protein. Proteins are mainly involved in the architecture of the cell (Radwan, Essawy, Abdelmeguied, Hamed, & Ahmed, 2008). In early study, we observed a decrease in globulin in exposed cases to E.M.F. The decreases may have resulted from disturbed protein synthesis in the liver. These results was in agreement with another published wrote (Boguslaw Kula, Sobczak, Grabowska-Bochenek, & PISKORSKA, 1999) he invesgate to evaluate some biochemical parameters in the serum of steelworkers exposed to electromagnetic field, the study was performed in steelworkers (men only) who worked in a tool shop and heavy processing shop We found significant decreases in the levels of total protein, β- and γ-globulins, and in the activities of γglutamyltranspep. In the present study, serum transaminases (AST&ALT), ALP and bilirubin exhibited a general increase in exposed cases to E.M.F compared to the controls. After exposure to mobile phone radiation in the liver of male rats (Fatma et al., 2015) in their study observed the increases of liver tissue significantly and liver enzyme activates ALAT, ASAT and ALP in serum and increased oxidative stress marks (MDA&H2O2). The physiological importance of bilirubin is considered from a naturally occurring antioxidant (Stocker, Yamamoto, Mc Donagh, Glazer, & Ames, 1987) thus it will have a role in protecting lipoproteins and lipid from against oxidation. Bilirubin concentrations may be decreased in this study due to a reflection of hepatic dysfunction may which could be related with reduced levels in lipid peroxidation. Researchers reported that the rising in elevated blood cholesterol concentration due to a low level of bilirubin which prevented solubilization of cholesterol and its clearance through the bile**.** Due to no significant changes found in both HDL and total cholesterol, this study does not support this results (Ockner, Manning, & Kane, 1982). The findings suggested that Olive oil suppresses E.M.F exposure in cases may be, by modulating the antioxidant defense status of the children in response to their antioxidant action. The decreases may have resulted from disturbed protein synthesis in the liver. These results is in agreement with published work (Boguslaw Kula et al., 1999). The result shows a significant rise of blood urea thats is a good indicator for kidney disorders. Urea is the principle end product of protein catabolism. Acceptable postulate to interpret the elevated levels of urea thats due to the enhanced protein catabolism accelerated amino acid deamination for gluconeogenesisis (Bishop, Duncan, Brett, & Lawrence, 2004). Also Uric acid is the end product of the catabolism of tissue nucleic acid (Osibemhe. Martin & Okolie, 2012)**.** The increment in uric acid concentration might be due to the raising of uric acid levels or to by either inability of excretion or overproduction causing degradation of purines (Reddy, Monigari, & Hande, 2015). For creatinine, the data show the increment in concentration that response to E.M.F exposure was in agreement with published result (Ragy, 2015) his work was designed to study the effects of exposure to mobile phone emits 900-MHz EMR on the brain, liver and kidney of male albino rats. Thirty male adult rats were randomly divided into four groups (10 each) its results show significantly increased in urea, creatinine and corticosterone. Creatinine is considered the last variable of non-protein nitrogenous blood constituents. Creatinine appears in amount proportional to the body's muscles mass (Sharma & Singh, 2014). The high creatinine concentration is associated with abnormal renal function, particularly as it associates to glomerular function (Bishop et al., 2004). Antibodies present in the human body, especially in the brain increase the cellular damaging effect of E.M.F by enhance free radical activity in the cells (Panagopoulos, 2011).

Chapter 5
Conclusions and Recommendations

Chapter 5
Conclusions and Recommendations

The evaluation of human exposure to new telecommunication systems, which are becoming more widespread, which is an important issue. In fact, these new systems usually operate a rather complex environment where many field sources and scattering objects are present. In this situation, accurate investigations are needed to assess if human exposure can give rise to health risks and to verify if existing protection standards are still adequate. This study aimed to study the effects of mobile phone base station radiation on children blood numerical and experimental. In analytical assumption, the exposure has been analyzed coupling the FDTD method and with using matlab program. One -layered structure representing simplified model of human body tissue irradiated by mobile phone base station is investigated. The layers represent the (blood, kidney, liver and thyroid) tissue. Electric, magnetic fields, Specific absorption rate (SAR) and power density have been drawn with respect to time steps. Experimental side aimed to study the effects of non- ionizing radiation emitted from the base station on the health of children and possible protective role of Olive oil supplementation provided to the target children. We measure blood picture and biochemical parameters in the serum of children (6-12 years) exposed to electromagnetic field (electric field strength of 60 - 130 V/m) and study the therapeutic action of Olive oil (2.5 ml / day) for 5 weeks against harmful effect induced by electromagnetic field. We found that the electromagnetic field exposure increased the concentrations of serum glucose, triglycerides, total cholesterol, albumin, urea, uric acid and creatinine but total protein, globulin and Thyroid-Stimulating Hormone (TSH) were decreased. Activities of serum aspartate a minotransferase (AST), alanine a minotransferase (ALT), alkaline phosphatase (ALP) and bilirubin were increased. Concerning hematological parameters, the more obvious changes were observed in the increment of WBC, lymphocyte, MCV, MCH, MCHC, and decrease in hematocrit, Hb, RBC, and PLT count in response to the exposure to E.M.F. Improvement after supplementation suggests that Olive oil can ameliorate hazards of such radiation on hematological and biochemical indices.

The inhabitants around mobile base station antennas significantly complain or develop headache, memory changes, tremors, dizziness, depressive symptoms and sleep disturbance than controls. Also, there are some effects of radiation emitted from these antennas on neurobehavioral performance. Therefore, the study recommends Annual monitoring of RFR emitted from the mobile phone base station antennas should be carried out as their values may become higher due to the expected extensive future use of mobile phones and hence more activity and more arising emissions leading to increase in incidence and severity of neurobehavioral disorders among inhabitants around these stations. Also, the study advised to include, liver, kidney and thyroid function test, in periodic medical examination of people exposed to non-ionizing radiation emitted from base station. Olive oil supplementation may ameliorate liver, kidney and thyroid activity in such peoples. However further investigation is required to clarify the degree of liver, kidney and thyroid function alteration by electromagnetic field emitted from base station and the relation between Olive oil supplementation and liver, kidney and thyroid hormone.

The future work will be addressed the effect of electromagnetic waves produced from mobile phone base station on other tissues in two and three dimensions using FDTD method. Experimentally can be study the mobile phone base station radiation effects on sex horomones. Thermal effect and raise in temperature on life tissue also could be study.

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Appendexis

Appendix (1): Hilsinki Commiteed for Ethical Approval

المجلس الفلسطيني للبحث الصحي

Palestinian Health Research Council

تعزيز النظام الصحي الفلسطيني من خلال مأسسة استخدام المعلومات البحثية في صنع القرار

Developing the Palestinian health system through institutionalizing the use of information in decision making

Helsinki Committee

For Ethical Approval

Date: 03/10/2016 **Number:** PHRC/HC/180/16

Name: MOHAMMED A. ABUJAMI الاسم:

We would like to inform you that the committee had discussed the proposal of your study about:

نفيدكم علماً بأن اللجنة قد ناقشت مقترح دراستكم حول:

Study the effects of electromagnetic waves on the blood of children and the therapeutic role of olive oil to limit the impact in Gaza Strip

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/180/16 in its meeting on 03/10/2016

و قد قررت الموافقة على البحث المذكور عاليه بالرقم والتاريخ المذكوران عاليه

Signature

Member **Member**

3/10/2016

Chairman

Genral Conditions:-

1. Valid for 2 years from the date of approval.
2. It is necessary to notify the committee of any change in the approved study protocol.
3. The committee appreciates receiving a copy of your final research when completed.

Specific Conditions:-

03/10/16

E-Mail:pal.phrc@gmail.com

Gaza - Palestine غزة - فلسطين

شارع النصر - مفترق العيون