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Study the Effect of Electromagnetic Radiation on Fetal Spleen Tissue at 500 MHz Simulating by FDTD

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Khitam Y. Elwasife*[1], Huda M. Abudaf[2]

[1] Department of Physics, College of Science, Islamic University, Gaza, Palestinian Territory,
College of medicine, Islamic University, Gaza, Palestinian Territory

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ABSTRACT

The ever-rising diffusion of electromagnetic radiation has brought about an increased concern on human health. Furthermore, technological devices have become essential components of daily life. However, their deleterious effects on the body, particularly on the human life tissue. Also, these electromagnetic waves can cause in life tissue. In this work electric and magnetic fields through spleen fetal tissue have been investigated. Concerning numerical modeling, the power density and specific absorption rate in a spleen fetal tissue by dielectric property at 500MHz studied. It is generally computed using finite difference time domain methods (FDTD) in one and two dimension. Results show that electromagnetic radiation penetrates the fetal spleen tissues and attenuate fast to reach zero at the inner of tissue. The absorbent power and specific absorption rate (SAR) show maximum at the interface.

INTRODUCTION

High frequency electromagnetic fields are parts of the electromagnetic spectrum between the low frequency and the optical part of the spectrum. As this part of the spectrum is used for broadcasting and telecommunication, it is termed radio frequency (RF). The RF spectrum is defined in the frequency range between 9 kHz and 300 GHz[1]. An elevate using electromagnetic radiation with high power is important to coincide and agree the limits of safe exposure with respect to thermal hazards. The amount of energy absorbed by tissue depends on many factors including frequency, dielectric property of the tissue, irradiating time exposure, intensity of electromagnetic radiation, and water content of the tissue [2]. For this reason, public organizations throughout the world have established safety guidelines for electromagnetic wave absorption values. Since specific absorption rate (SAR) is a physical quantity, which causes tissue heating because of radiofrequency exposure, the safety guidelines on localized SAR for wireless applications should be determined in relation to temperature rise in the head. This is because the biological hazards are mainly owing to temperature rise in the tissue. The Changes in the dielectric properties of rat prostate ex vivo at 915 MHz during heating has been evaluated [3]. It found that the temperature coefficients can be utilized in microwave treatment planning programmers to provide insight into the effects of dielectric changes that arise during microwave thermal therapy of prostate cancer. In this work we studied the effect of electromagnetic waves produce from mobile phone on human prostate tissue, computation finite difference time domain method simulations were run for mobile phone radiation of the human prostate which frequency was 0.9 GHz continuous waveform source. The dielectric properties of human fetal tissues, including skin, muscle, heart, lung, liver, kidney, spleen, and brain, at frequencies from 100 kHz to 500 MHz has been Pregnant women are at risk of exposure to non ionizing and ionizing radiation resulting from necessary medical procedures, the diagnostic before the pregnancy is known. Nonionizing radiation includes microwave, ultrasound, radiofrequency, and electromagnetic waves, when exposure to ionizing radiation occurs, the total fetal radiation dose should be estimated and the mother counseled about the potential risks so that she can make informed decisions about her pregnancy management [5]. Several studies have reported that exposure to electromagnetic radiation results in oxidative stress in many tissues of the body. Exposure to electromagnetic waves is known to increase free radical concentrations and traceability and can affect the radical couple recombination. Elfide Gizem Kıvrak et al has been studied the highlight the impact of oxidative stress on antioxidant systems [6]. Besides technological developments in the world, technological devices are becoming ever more important in daily life. However, despite making life easier, they may also cause a number of health problems. In particular, the average age of beginning mobile phone use has decreased rapidly to elementary school age, and durations of exposure to EMF are also increasing. One study reported that extremely low exposure to EMF from mobile phones may cause health problems [7]. Kirimoto et al studied a period of two human provocation with static magnetic fields which investigated possible effects of Tran's cranial static magnetic field stimulation as a new non-invasive brain stimulation technique [8]. Sachiko Kodera et al computationally estimated the thermal time constants of temperature elevation in human head and rat models exposed to dipole antennas at 3–10 GHz. It found that the peak temperature elevation in the human brain was lower than that in the rat model because the difference in depth from the scalp [9]. In this work electric and magnetic field through spleen fetal tissue investigated by simulating spleen tissue using one and two dimension, also, the power density and specific absorption rate studied in the same supposed tissue.

Theory and model

Electromagnetic radiation projects may be modeled to study a value problems control by partial differential equations subject to initial boundary values. The spatial domain of the boundary value problem may be complicated in general, and the direct analytical solution. The study of a heterogeneous model for human tissue is a difficult theoretical task. Maxwell's equations are the basic equations to simulate human life tissue by finite difference time domain (FDTD)method[10] There have been used special models and techniques, each valid only in a limited range of frequencies or other parameters. A combination of techniques has been used to obtain SAR for different models as a function of frequency and time. Let us considered that electromagnetic radiation with 500MHz frequencies is incident vertically upon the interface spleen fetal tissue with dielectric properties shown in table (1).

Table No. 1: Dielectric properties of spleen fetal tissue

Tissue name	Conductivity σ_{sf} [S/m] at 500MH	Relative permittivity ε_{sf} at 500MHz
Air	0	1
Spleen	0.93	45.6

The permittivity and conductivity of spleen fetal tissue are different according changing frequency. The electric field is assumed to propagate in the z-direction with polarization at the x direction, where only E_x and H_y are not equal to zero and traveling in the z-direction [11]. Maxwell's equations considered in one dimensions. The time-dependent Maxwell's curl equations in general form as:

$$\nabla \times E + \mu \frac{\partial H}{\partial t} = 0 \quad (1)$$

$$\nabla \times H - \varepsilon \frac{\partial D}{\partial t} = \sigma E \quad (2)$$

Where D is the displacement vector, E is electric field, H is represent as magnetic field, and we assume that σ is the conductivity of tissue and ε is the real relative part of the permittivity tissue, the relationship between the variables used in this research is as follows:

$$\varepsilon_r^*(\omega) = \varepsilon_{sf} - j\frac{\sigma_{sf}}{\omega\, \varepsilon_0}$$

Where, ω is the radial frequency of the signal. The magnetic and electric fields do not vary in the x-y plane. The free space is considered as the exterior of the model with wave number $k_o = \omega\sqrt{\varepsilon_o \mu_o}$,although, we assume that ε_{sf} is the real relative part of the permittivity spleen fetal tissue, σ_{sf} is the conductivity of spleen fetal one and according to equations (1,2) becomes:

$$\frac{\partial E_x(t)}{\partial t} = -\frac{1}{\varepsilon_o \varepsilon_{sf}} \frac{\partial H_y(t)}{\partial z} - \frac{\sigma_{sf}}{\varepsilon_o \varepsilon_{sf}} E_x(t) \quad (3)$$

$$\frac{\partial H_y(t)}{\partial t} = -\frac{1}{\mu_o}\frac{\partial E_x(t)}{\partial z} \qquad (4)$$

By using finite difference time domain method, the central difference approximations for both the temporal and spatial derivatives are obtained at $z = k\Delta z$ and $t = m\Delta t$, we have:

$$\frac{E_x^{m+1/2}(k) - E_x^{m-1/2}(k)}{\Delta t} = -\frac{1}{\varepsilon_o\varepsilon_{sf}}\frac{H_y^m(k+1/2) - H_y^m(k-1/2)}{\Delta z} - \frac{\sigma_{sf}}{\varepsilon_o\varepsilon_{sf}}\frac{E_x^{m+1/2}(k) + E_x^{m-1/2}(k)}{2} \qquad (5)$$

And

$$\frac{H_y^{m+1}(k+1/2) - H_y^m(k+1/2)}{\Delta t} = -\frac{1}{\mu_o}\frac{E_x^{m+1/2}(k+1) - E_x^{m+1/2}(k)}{\Delta z} \qquad (6)$$

where m is the time index and k is the spatial index, which indexes times t = $m\Delta t$ and positions $z = k\Delta z$. A one dimensional finite difference model studied for predicting electric and magnetic fields, Maxwell electric field equation becomes as rearranged equations (5) and equation (6) as a pair of computer update as:

$$\tilde{E}_x^{m+1/2}(k) = \frac{1 - \frac{\Delta t.\sigma_{sf}}{2\varepsilon_o\varepsilon_{sf}}}{1 + \frac{\Delta t.\sigma_{sf}}{2\varepsilon_o\varepsilon_{sf}}}\tilde{E}_x^{m-1/2}(k) - \frac{1/2}{\varepsilon_{sf}\left(1 + \frac{\Delta t.\sigma_{sf}}{2\varepsilon_o\varepsilon_{sf}}\right)}[H_y^m(k+1/2) - H_y^m(k-1/2)] \qquad (7)$$

$$H_y^{m+1}(k+1/2) = H_y^m(k+1/2) - \frac{1}{\sqrt{\varepsilon_o\mu}}\frac{\Delta t}{\Delta z}[\tilde{E}_x^{m+1/2}(k+1) - \tilde{E}_x^{m+1/2}(k)] \qquad (8)$$

The specific absorption rate (SAR) is typically averaged over the entire body or a smaller sample volume of 10 or 1 g of tissue (which one of these sizes the sample is depends on national rules). Equation 9 and equation 10 represent the power density and specific absorption rate in material.

$$p = E^2 \sigma / 2 \qquad (9)$$

$$SAR = \frac{p}{\rho} \qquad (10)$$

Which plot versus time steps?

RESULTS AND DISCUSSIONS

Simulation of a sinusoidal wave hits a life tissue that has different a dielectric constant according to different frequencies as shown in Table 1. The pulse is generated at the far left side with distance 40 cm and originates at cell number and propagates to the right. This is illustrated graphically. Notice that the waveform in the medium is maximum, absorbed at the boundary of tissue with air. power density and specific absorption rate have been evaluated in life tissue where the power density (W/m3) absorbed in the conductivity σ along the layer from the sinusoidal field of the amplitude E is given [12]. The dispersion relations in this model are denoted by equations (6,7), It must be solved numerically using simulation by finite difference time domain method to find the electric and magnetic field as a function of space step as appeared in figures below. A one dimensional equation by finite difference model for in spleen fetal tissues are appeared from the curve below. In software program, we considered time steps as 500 steps. Figure (1) illustrated the electric field through a spleen fetal tissue after 500 steps, It is clear that at the first tissue the electric field is very high compared with the last end of tissue. The distribution of magnetic field in spleen fetal tissue is very high compare with electric field at Tissue Exposure to electromagnetic radiation as shown in fig(2).In figure (4), a numerical analysis of specific absorption rate in spleen fetal tissue model exposed to electromagnetic radiation radiations are obtained as relation represent the specific absorption rate through the tissue after 500 time steps, the first beak is maximum at 0.34 W/kg, while the second peak was at 0.05W/kg. There are wide ranges between the two peak which clear that the effect of electromagnetic waves is big at the interface of tissue. The spleen fetal tissue absorbs radiations poorly due to its conductivity and the difference in the dielectric properties of the related tissues. In addition, the maximum SAR values are substantially higher for the heterogeneous model of tissue In figure(5,6), we suppose that Grid pixels in Y direction and Grid pixels in Y direction are 300 pixels, 2D of electric fields of elctromagnetic radiatio distribution in spleen fetal tissue (bone and line figure). Although, in figures (7,8), magnetic field in two dimension as X-Y plane through its distribution in spleen fetal tissue.

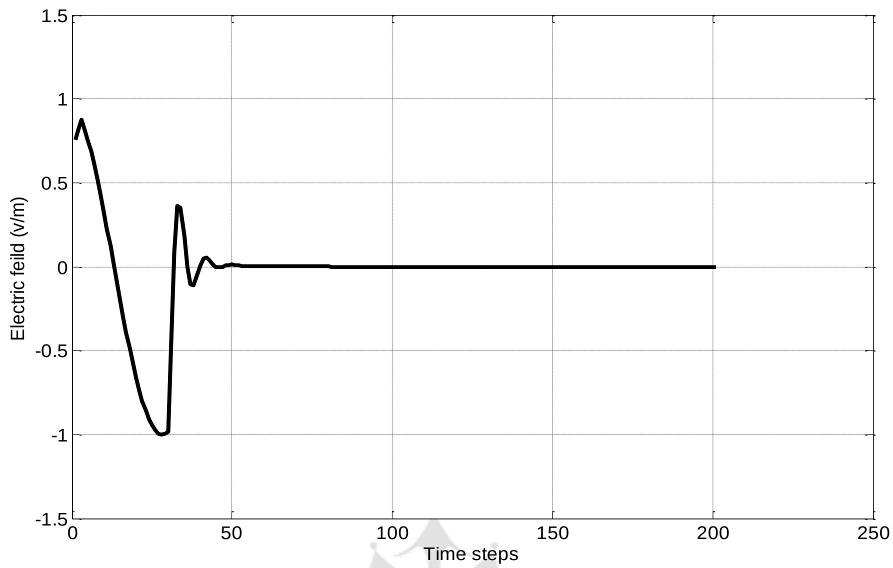

Figure No. 1: Electric field distribution in spleen fetal tissue

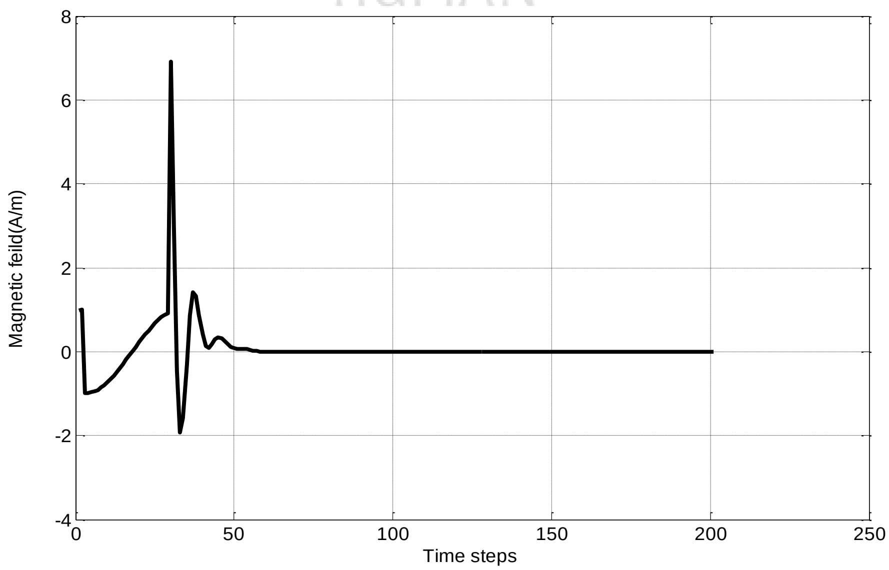

Figure No. 2: Magnetic field distribution in spleen fetal tissue

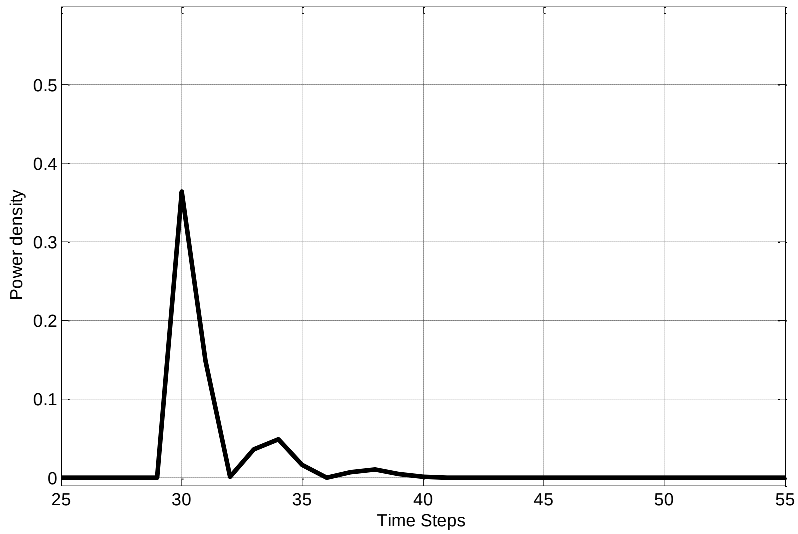

Figure No. 3: Power density of elctromagnetic radiation distribution in fetal splee fetal at 500 MHz

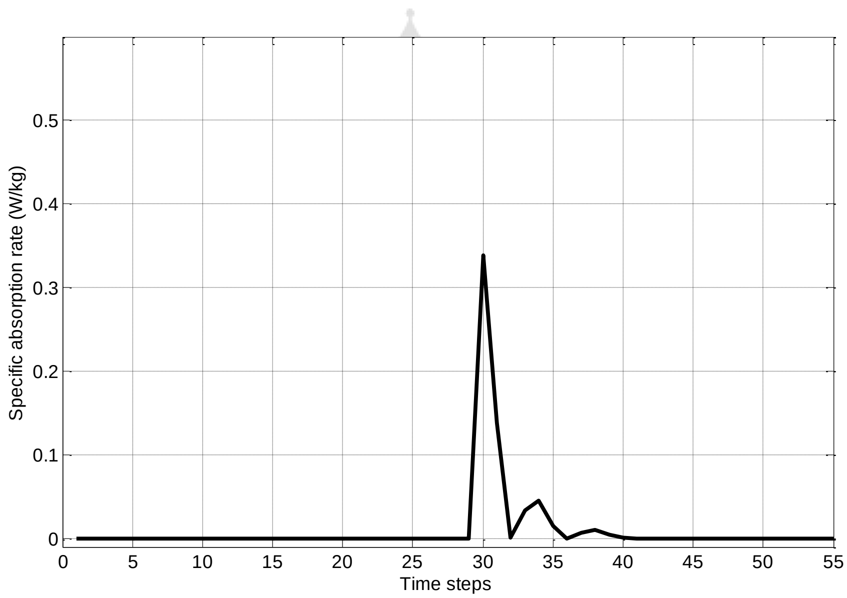

Figure No. 4: specific absorption rate of elctromagnetic radiatio distribution in spleen fetal tissue n at 500 MHz

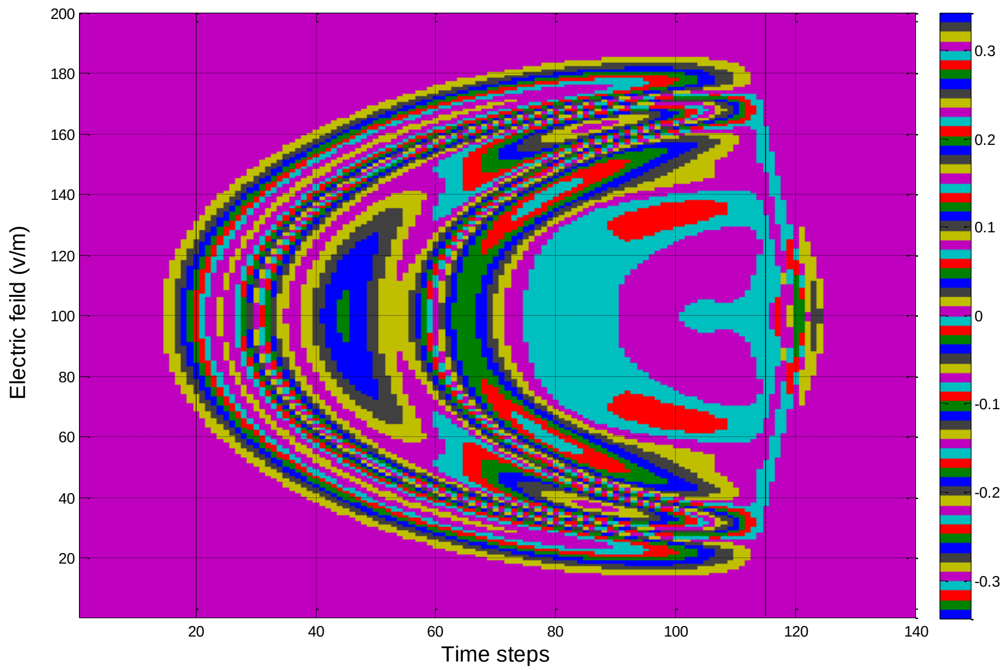

Figure No. 5: 2D of electric field of elctromagnetic radiatio distribution in spleen fetal tissue(line figure)

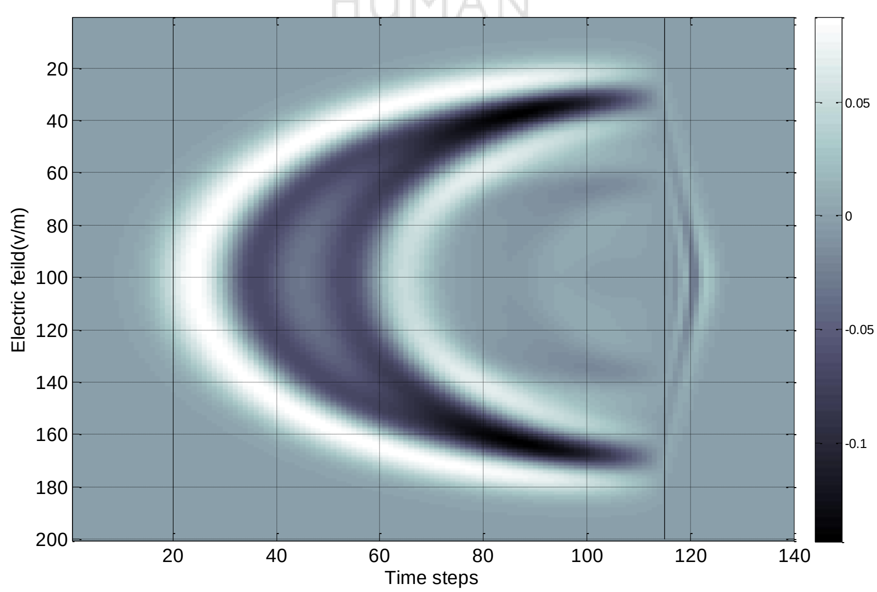

Figure No. 6: 2D of electric field of elctromagnetic radiatio distribution in spleen fetal tissue (bone figure)

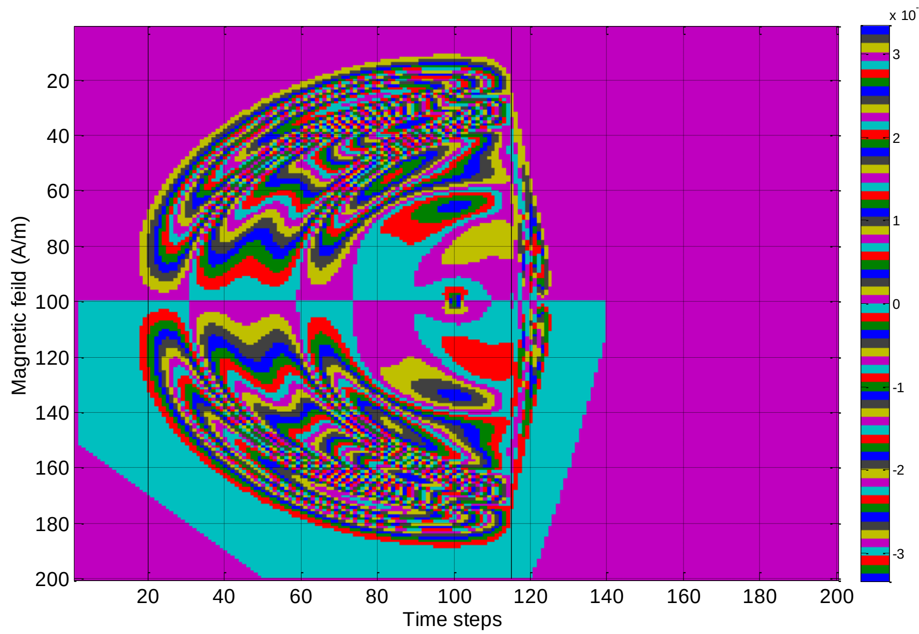

Figure No.7: 2D of magnetic field of elctromagnetic radiatio distribution in spleen fetal tissue(line figure)

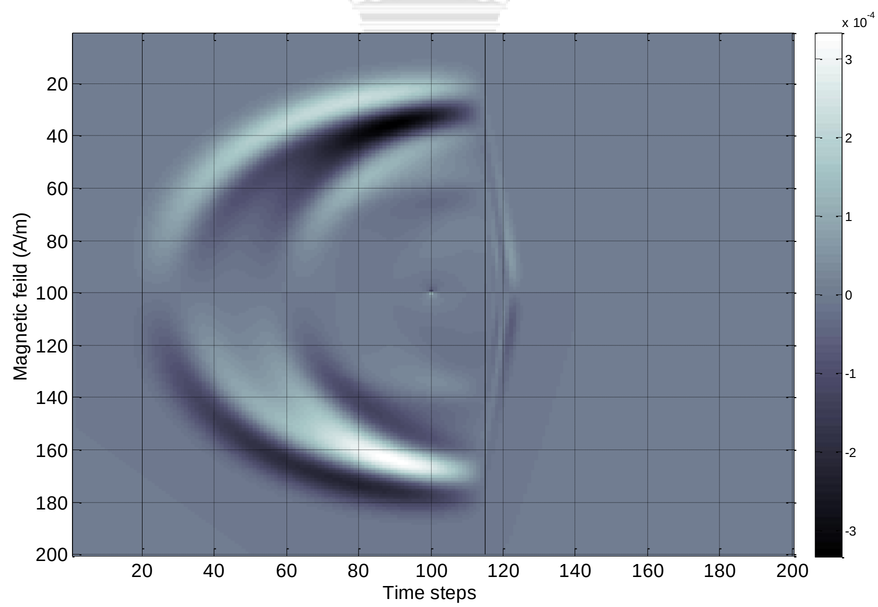

Figure No. 8: 2D of magnetic feild of elctromagnetic radiatio distribution in spleen fetal tissue(bone figure)

CONCLUSION

Depressive characteristic of spleen fetal tissue were numerically studied, it has been studied that it is possible to plot electric field and magnetic field distribution through the human tissue in one and two dimension (1D, 2D) by time steps using software program. According the dielectric properties of spleen fetal tissue at specific frequency 500MHz, the maximum density of specific absorption rate is 0.34W/kg at the moment of striking the spleen fetal tissue and damping according to the time steps. While the first power density beak Is 0.37 W/m. It is indicate that the electromagnetic radiation absorbed by the tissue. These findings should be helpful for extrapolating effect of electromagnetic radiation on another humane tissue.

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