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RESEARCH ARTICLE

HEALTH EFFECTS DUE TO NON-IONIZING ELECTROMAGNETIC WAVES IN THE FREQUENCY RANGE (30 kHz - 70 kHz)

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ABSTRACT

The interactions of electromagnetic waves emitted by radiator with the biological tissues are studied. The photon of electromagnetic waves (EMW) are scattered by the different tissues inside the body and created the phonon. In this process, energy is transferred from one tissue to another and in every step; energy is absorbed by the tissues. In this manuscript, the penetrated electric field of selective tissues of human body and absorption of energy has been calculated and the calculated electric field and specific absorption rate (SAR) are compared with the International permissible limit given by some International Commission of Non-ionizing Radiation Protection (ICNIRP) and World Health Organization (WHO) etc. It is found that penetrated electric field inside the tissues represents that frequency 30-50 kHz are harmful for some tissues while specific absorption rate (SAR) represents that (30-70) kHz are harmful for cerebella spinal fluid, gall bladder bile, and body fluid etc. of the human beings. After analysis, it is concluded that people should keep away from the radiator.

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INTRODUCTION

The signals (EMW) penetrate inside the human beings and due to the propagation of waves; cells of tissues of human beings absorb the energy. The energy of the tissues becomes greater to its natural value. The excess amount of energy may affect the health of tissues or cells. According to James, E. exposure of extremely-low frequency electromagnetic fields (ELF-EMF), epigenetic toxicants affect one of four potential cell states, namely alteration of cell proliferation, cell differentiation, programmed cell death (apoptosis) or adaptive responses of differentiated cells (James E. *et al*, 2000). These low frequency electromagnetic waves (EMW) exposure conditions are not expected to significantly modulate innate immune signaling (Bouwens, M. *et al*, 2011). Ozen S. observed that current densities, in the frequency range from 50 Hz up to 100 kHz, induced by external electric and magnetic fields to child and adult human body, were investigated, as in residential areas. The finding of Adamos shows that 1 °C temperature increase in the tissues around the tips of the generic implant can be reached for field strengths much smaller than 1% of those in the basic restrictions (Adamos *et al*, 2011). The maximum SAR values increase with the increase in conductivities of human body tissues and decrease with the increase in relative permittivity of human body tissues. A variation of up to 20% in conductivities and relative permittivity, alone or simultaneously, always causes a variation of SAR to be less than 10%. As far as the compliance of safety is concerned,

the maxima of 1-g-averaged and 10-g-averaged SARs can reach 3.16 and 0.89 W/kg at the input power of 25 mW (Xu L. *et al*, 2009). A 1439 MHz TDMA field did not induce observable changes in the permeability of the BBB, morphological changes in the cerebellums, or body mass changes in rats, as evaluated by the conventional methods (Tsurita G. *et al*, 2000, Blank, M. 2009).

The calculation of the analytical solution has been obtained by (Caorsi *et al*, 1999) generalizing a known procedure that deals only with lossless materials and the model makes possible the calculation of the SAR for realistic human tissues. EMF can also affect on the material particles conductive nanoparticles may enhance tissue heating during radiofrequency (RF) irradiation. Specific absorption rate (SAR) is known to rise with the electrical conductivity of tissue. Electrode polarization effects increased with carbon concentration. The real parts of the permittivity of the colloids increased with carbon concentration. The static conductivity rose linearly with carbon concentration, doubling from 0 to 93 mM. The SAR of the colloids is expected to increase with RF frequency, based on the properties of the imaginary part of the permittivity (Gach H.M. 2011, Goodman, R. 2011).

MATERIAL AND METHODS

In this manuscript, the power of the radiator used by navy is taken 10 kW. Heating of biological tissue is a consequence of high or low water content tissues. The amount of heating produced in a living organism depends primarily on the intensity of the radiation once it has penetrated inside the body. The proposed approach is useful to predict the induced electric

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field around the navy radiator, penetrated electric field inside the body and specific absorption rate (SAR) of the tissues of the human body. Suppose that a stream of photons is incident around the human body. The photons are a result of the electromagnetic waves emitted from the radiator. The waves produced by the antenna have a spherical wave front. The incident electric field (E_0) around the radiator of power P is given by

$$E_0 = \frac{7.746\sqrt{P}}{(r+x)} \dots\dots\dots (1)$$

Where x be the distance from the radiator and r be the radius of cross section of the radiator which emit spherical wave front (Kumar, V. *et al* 2008, 2010 & 2012). The induced electric field around the radiator is,

$$E_0 = 774.6/(r+x) \dots\dots\dots (2)$$

For the tissue of biological material well inside the boundary, field strength will further reduce due to dissipation during propagation inside the body. The electric field decreases exponentially with distance from the boundary and are given by

$$E_z = E_0 e^{(-z/\delta)} \dots\dots\dots (3)$$

Where E_z is the field inside the depth z and E_0 is the magnitude of field just inside the boundary. The skin depth δ is the distance over which the field reduces to $\frac{1}{e}$ (= 0.368) of its

value just inside the boundary. The skin depth again depends upon frequency of radiation. For biological materials, it is given by

$$\delta = \frac{1}{\omega q} \dots\dots\dots (4)$$

$$q = \left[\frac{\epsilon\mu}{2} \left\{ (1 + P^2) - 1 \right\} \right]^{\frac{1}{2}} \dots\dots\dots (5)$$

Where, $P = \frac{\sigma}{\omega\epsilon} \dots\dots\dots (6)$

Where ω is angular frequency of radiation, ϵ is permittivity, μ is the permeability and σ is conductivity of biological material.

Specific absorption rate (SAR)

The specific absorption rate is defined as the time derivative of the incremental energy (dW) absorbed by or dissipated in an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It can be defined as

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) \dots\dots\dots (7)$$

$$SAR = \frac{d}{dt} \left(\frac{dW}{\rho dV} \right)$$

By using Pointing vector theorem for sinusoid ally varying electromagnetic fields. We get

$$SAR = \frac{\sigma E_z^2}{\rho} \dots\dots\dots (8)$$

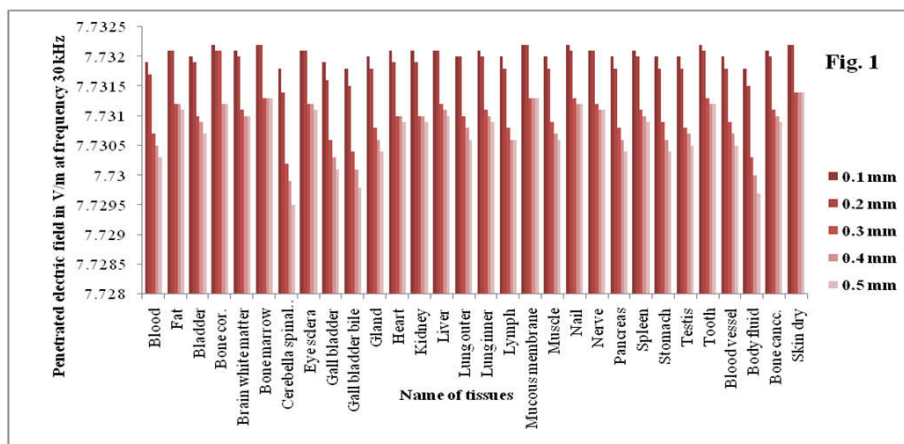
Where σ is the conductivity of the material and E_z is the field inside that material. This relation represents the rate at which the electromagnetic energy is converted into heat through well-established interaction mechanisms. It provides a valid quantitative measure of all interaction mechanisms that are dependent on the intensity of the internal electric field (Roje V. 2003).

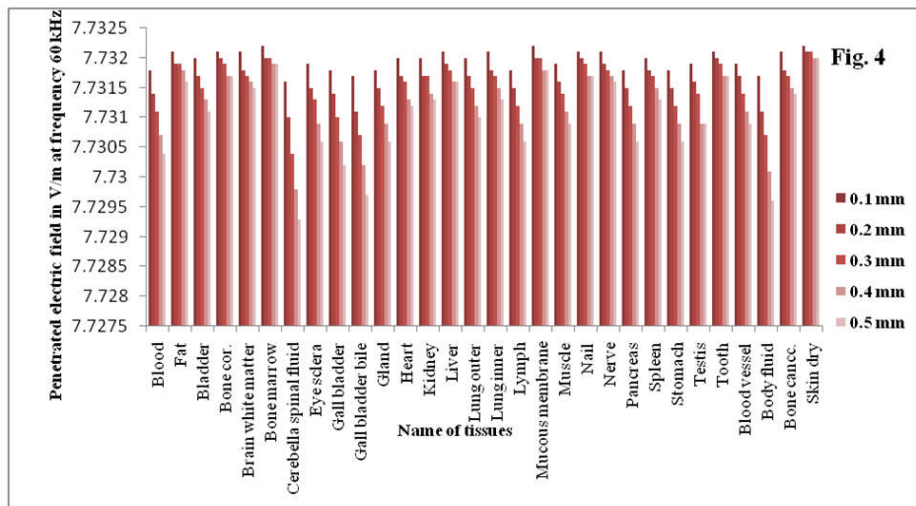
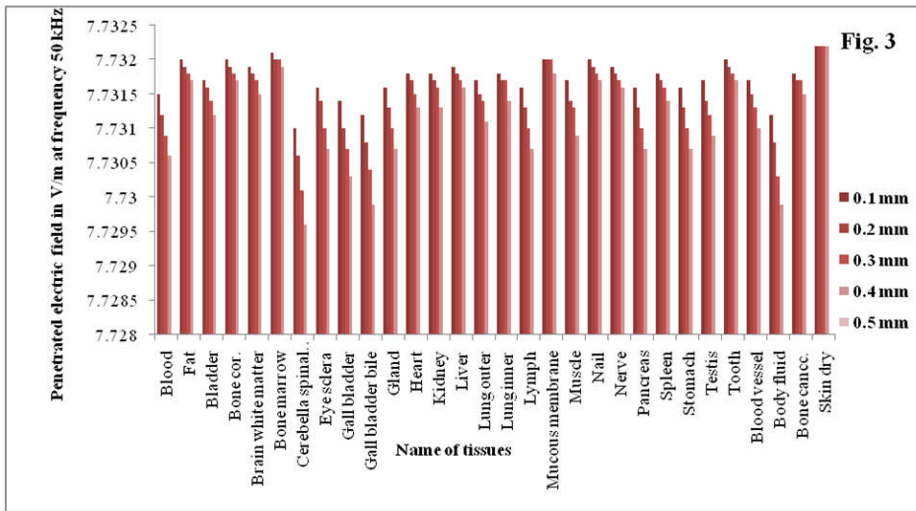
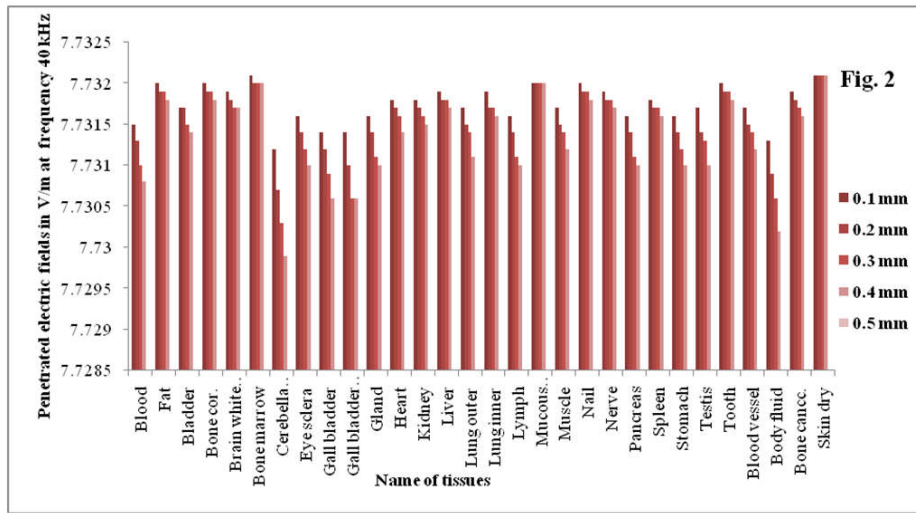
RESULTS

Incident electric field in air from radiator is (E_0) = 7.7322 V/m at power (P) = 10 kW and distance from the radiator is 100 meter,

DISCUSSION

In many times, it is seen that public live within the range of 100 m distance from the radiator because sometimes radiators are situated in thickly populated area .The radius of cross section of radiator which we are using for our study is 10 cm. In this manuscript, the power of radiator is taken 10 kW. The People who live near the sea cost are exposed by the radiation (EMW) of radiator. The electric field induced by the radiator is taking for this study. This electric field produces an electric blanket around the people of sea cost. Fig. 1 represents the induced electric field inside some selected tissues of human beings due to the exposure of 30 kHz radiation of radiator.





According to ICNIRP, the safe limit of all head and body at 30 kHz EMW for occupational exposure and general public exposure are 8.1 V/m and 4.05 V/m respectively (I.C.N.R.P. 2010), and this radiation is harmful for all tissues of head and body for general public exposure. This radiation is harmful for the tissues of bone cortical, bone marrow, mucous membrane, nail, and tooth, fat, brain white matter, eye sclera, heart, kidney, liver, lung inner, nerve, spleen, bone canceleous tissues. Fig. 2 represents the penetrated electric field due to the exposure of 40 kHz radiation. The safe limit of all head and

body for this frequency EMW for occupational exposure and general public exposure are 10.8 V/m and 5.4 V/m respectively, and this radiation is harmful for all tissues of head and body for general public exposure. The radiation is harmful for bone marrow, mucous membrane, skin dry, fat, bone cortical, brain white matter, kidney, liver, lung inner, nail, nerve, spleen, tooth bone canceleous tissues. Fig. 3 shows the induced electric field inside the tissues of human beings due to the exposure of 50 kHz radiation of radiator. The safe limit of all head and body at 50 kHz for occupational exposure and

general public exposure are 13.5 V/m and 6.75 V/m respectively, and this radiation is harmful for all tissues of head and body for general public exposure. The radiation is harmful for the bone marrow, mucous membrane, skin dry, tissues fat, bone cortical, brain white matter, liver, nail, nerve, spleen, tooth, bone canceleous, skin dry tissues. For 60 kHz radiation, the safe limit for electric field of all head and body occupational exposure and general public exposure are 16.2 V/m and 8.1 V/m respectively. After comparing the safe limit result with the calculated result given in Fig. 4, it is seen that 60 kHz radiation is safe for all tissues of head and body for general public exposure. The safe limit of all head and body at 70 kHz radiation for occupational exposure and general public exposure are 18.9 V/m and 9.45 V/m respectively. Fig. 5 represents that the radiation is safe for all tissues of head and body for general public exposure. When these intermediate frequency (30 kHz-70 kHz) electromagnetic waves propagate from the skin to different tissues, the energy is absorbed by the tissues of the body. The specific absorption rate (SAR) of the tissues are calculated by the equation (8) and represented by the Figures 6 - 10 due to the propagation of electromagnetic wave of frequencies 30 – 70 kHz respectively. According to some International agencies as WHO, ICNIRP, the specific absorption rate (SAR) becomes harmful after 0.08W per kg, of the whole body weight. It means that, when SAR becomes greater to 0.08 W/kg. It may be harmful for the tissues life of the human body.

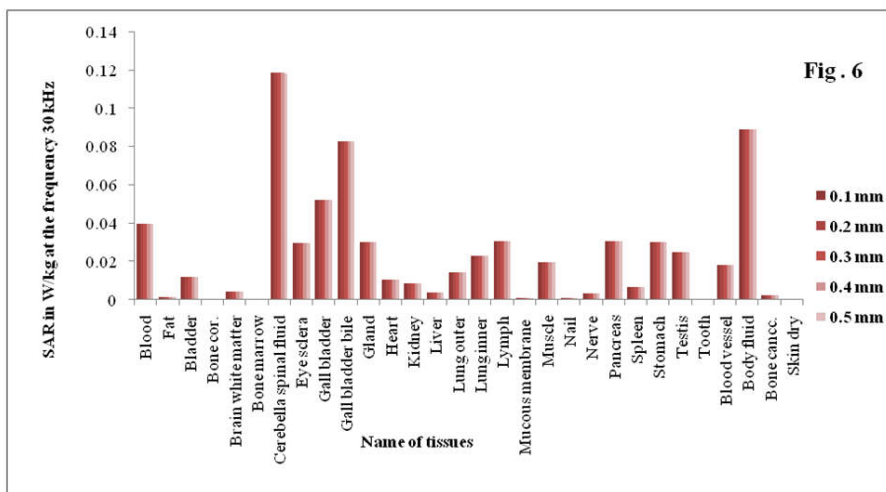
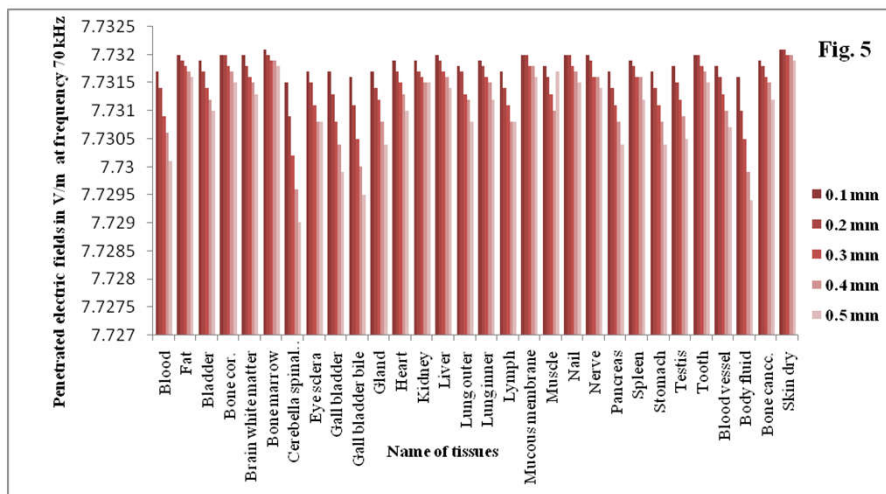
The safe limit is taken from ICNIRP guidelines. The radiators are generally situated near sea cost, thus the calculation are useful for the people living near sea cost.

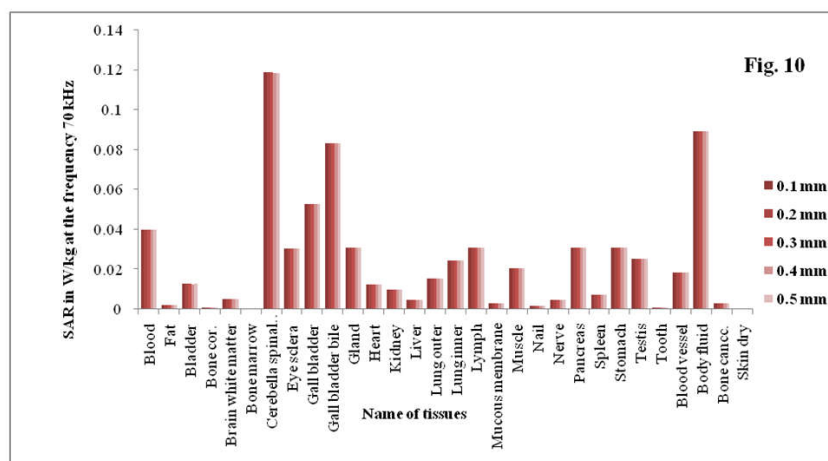
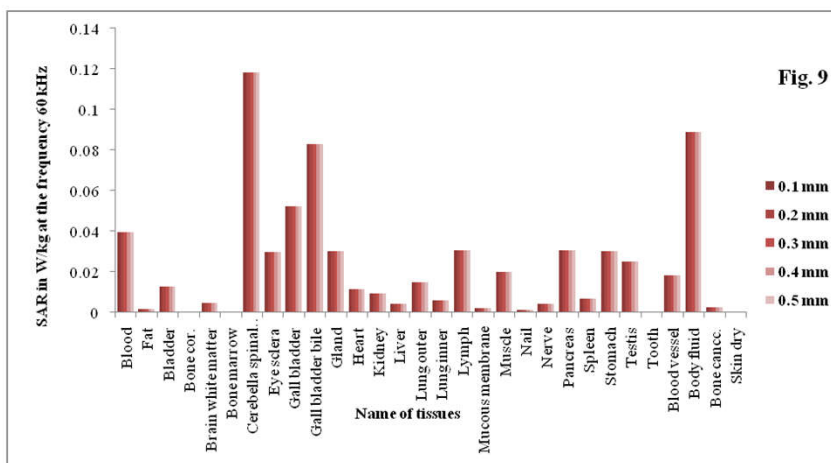
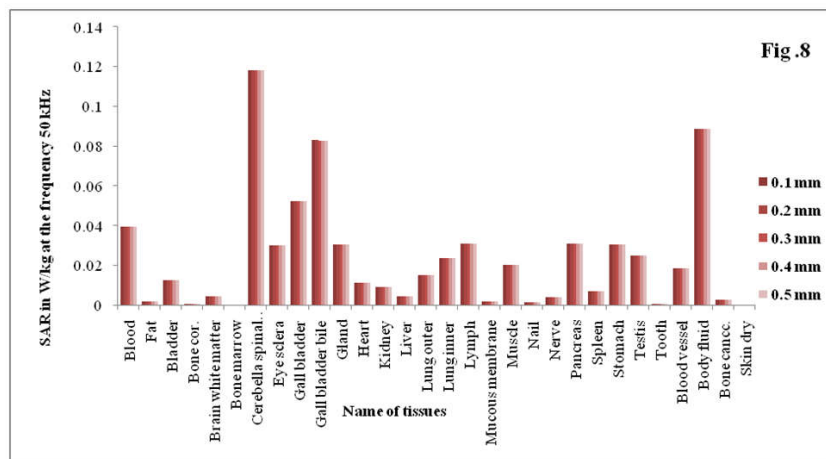
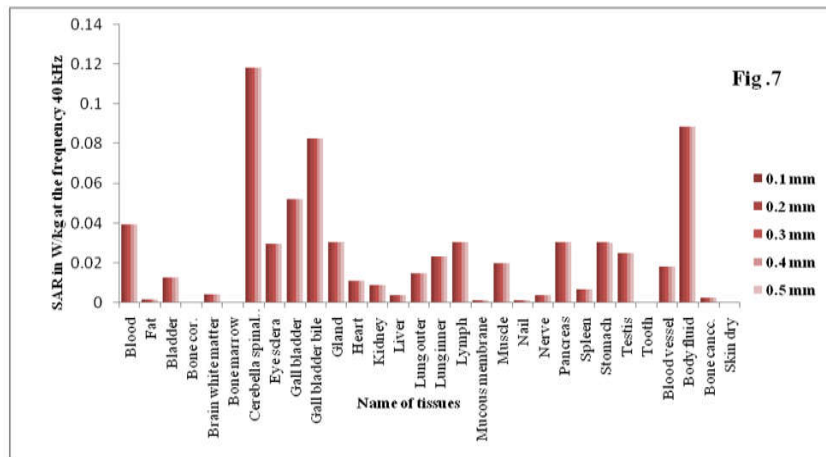
Conclusion

From the above analysis, it is concluded that Fig. 1, 2 & 3 represent that 30, 40 and 50 kHz frequency of EMW of radiator are harmful for all selected tissues of head and body of the human beings. Fig. 4 & 5 show that 60 kHz & 70 kHz frequency EMW of radiator are safe for all tissues of head and body. After observing the figures of Specific absorption rate (SAR), it is found that radiations are more harmful till 100 m distance from the radiator for the body tissue cerebella spinal fluid, gall bladder bile, and body fluid, till 0.1 mm depth to 0.5 mm depth inside the body. India and other European countries generally used the EMW in the frequency range of 30 - 70 kHz for broadcasting, navigation beacons etc. The above analysis represents that the general public and workers should keep away from the radiator. This approach may be useful in terms of monitoring about the harmful effects of EMW and public information about the level of protection from the exposure to the radiator.

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