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RESEARCH ARTICLE

HEALTH EFFECTS ON CHILDREN DUE TO ELECTROMAGNETIC WAVES OF RADIO BROADCASTING AT THE FREQUENCY 230 kHz, 250 kHz & 283.5 kHz

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Abstract

In modern communication, the numbers of towers which radiate electromagnetic energy are increasing day to day continuously. These towers are situated in the populated area. These non-ionizing electromagnetic radiations affect the health of human beings special on the children health because children are more sensitive. In this manuscript the health effects on the children due to EMWs of frequency 230 kHz, 250 kHz & to 283.5 kHz are studied. These electromagnetic waves spread in the atmosphere and incident on the children. When the incident EMW penetrates, it's induced the electric field inside the tissues of the body of children. The incident and penetrated electric fields inside the tissues are calculated and compared with the International agencies as ICNIRP, WHO, NRPB etc., and found that EMWs of given frequencies are harmful for the tissues like body fluid, cerebral spinal fluid, gall bladder bile and vitreous humor.

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Introduction

In radio broadcasting services, the non-ionizing electromagnetic waves are used for communication of signals. The People who are living around the radiators are affected by these waves .In this manuscript 230, 250 and 283.5 kHz frequency of electromagnetic radiation are used for this study because these frequencies are generally used for communication. The EMR affects the health of the people especially on children. The immune system of children is lower than the adult person. The purpose of this manuscript is too aware the children about the harmful effects of radiation of the radiator/towers emitted non-ionizing electromagnetic field (NIEMF). When these EMW penetrate inside the body of children, its produce electric field inside the tissues. The excess amount of electric field increases the amount of absorption of energy inside the tissues. The energy of cell becomes more to its required natural energy.

Review of literature

In today's world, technologic developments bring social and economic benefits to large sections of society; however, the health consequences of these developments can be difficult to predict and manage. With rapid advances in electromagnetic field (EMF) technologies and communications, children are increasingly exposed to EMFs at earlier and earlier ages. Consistent epidemiologic evidence of an association between childhood leukemia and exposure to (Kheifets L et al., 2005) extremely low frequency (ELF) magnetic fields has led to their classification by the International Agency for Research on Cancer as a "possible human carcinogen." Concerns about the potential vulnerability of children to radio frequency (RF) fields have been raised because of the potentially greater susceptibility of their developing nervous systems and their brain tissue is more conductive, RF penetration is greater relative to head size, and they will have a longer lifetime of exposure than adults. To evaluate information relevant to children's sensitivity to both ELF and RF EMFs and to identify research needs.

Static fields produce health effects only in very rare and exceptional circumstances at extremely high field intensities. As for low-frequency EMF, the results of epidemiological research with respect to childhood leukemia

prompted the International Agency for Research on Cancer (IARC) in 2001 to classify these fields as “possibly carcinogenic to humans”. At high intensities, the generation of heat is the principal effect. Some recent epidemiologic studies suggest an association between lymphatic and hematopoietic cancers and residential exposure to high-frequency electromagnetic fields (100 kHz to 300 GHz) generated by radio and television transmitters. The risk of childhood leukemia was higher than expected for the distance up to 6 km from the radio station (Michelozzi, P. et al., 2002, Otto, M., Von Mühlendahl, K.E., 2007). Childhood defects can result from genetic or epigenetic damage and from effects on the embryo or fetus, which may both be related to environmental exposure of the parent before conception or during the pregnancy (Calvente, I., et al. 2010).

The comparison of specific absorption rate (SAR) induced in a child-sized (CS) head and an adult head using a dual-band mobile phone. The differences between the results for adult and CS or CL heads are given at 900 and 1800 MHz's, No important differences are noted for the peak SAR averaged over 10 g (SAR10 g), between the two adult head models, as well as between the two child head models. The peak SAR10 g in the brain of the CS or CL head is slightly more significant than that for the adult one (Lautru, H.A., et al. 2005). Concern is growing about exposure to electromagnetic fields and male reproductive health. In all age groups, there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields. However, the degree of exposure to radiofrequency radiation and the number of children were not associated (Baste, V., et al. 2008). A possible association between measured exposure to RF EMF fields and behavioral problems in children and adolescents, 1498 children and 1524 adolescents were randomly selected from the population registries of four Bavarian (South of Germany) cities. Overall, exposure to radiofrequency electromagnetic fields was far below the reference level. Seven percent of the children and 5% of the adolescents showed an abnormal mental behavior (Thomas, S., and et al. 2010). The causal, uncontrolled expositions may cause unexpected harmful effects. The problem of safety and therapeutic usage of different EMF needs further extensive studies (Stankiewicz, W., et al. 2009).

The result of the experiment on school children's living in the area of the, Skrunda radio location station (RLS) in Latvia. Motor function, memory and attention significantly were differed between the exposed and control groups. Children living in front of the RLS had less developed memory and attention, their reaction time was slower and their neuromuscular apparatus endurance was decreased (Kolodynski, A., Kolodynska, V., 1996).

There are difference between the energy absorptions of EMW of adult and children. The differences in electromagnetic (EM) energy absorption between adults and children during cell phone usage. Some published studies report higher specific absorption rate (SAR) in children and explain this based on smaller head size. More recently, age dependent changes of the dielectric tissue parameters have again ignited the discussion. The comprehensive review of the current state of knowledge about the parameters and mechanisms affect in the exposure of the mobile phone user with special focus on the exposure of children. Discussed are the absorption mechanism, tissue parameters, the effect of the pinna, and the uncertainties associated with head models based on spheroids, scaled adult heads, and magnetic resonance imaging (MRI) data of children (Christ, A., Kuster, N., 2005). Two children sustained full-thickness burns as a result of being placed in microwave ovens. Well demarcated burns occurred on the skin surfaces closest to the microwave-emitting devices. Morbidity was limited to complications of direct thermal effects. One of the children sustained a distinctive pattern of relative sparing of tissue layers without electrical burn features, such as nuclear streaming and charring, at the entrance site. In both instances eventual identification of this unusual etiology was initiated by child abuse concerns (Alexander, .R.C., et al. 1987).

Material and Methods

In this manuscript the power of transmission towers which radiate 230 kHz, 250 kHz and 283.5 kHz is 10 kW. The EMW of navigation is incident on the human body. The proposed approach is useful to predict the induced electric field around the tower, penetrated electric field inside the body and specific absorption rate (SAR) of the tissues of the human body. The waves produced by the dipole antenna have a spherical wave front .The incident electric field (E_0) around the radio transmitter 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 tower and r be the radius of cross section of the dipole antenna which emit spherical wave front (Kumar, V., et al 2008). The induced electric field around the transmitter of 10 kW is,

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

Actually, these radiations are used for navigation .It means, the radiation should more effective for the children living very near from the radiator. Thus 100 m distance from the radiator is taken for this study. The radius of cross

section of transmitting antenna which we are using for our study is 10 cm .Now for the tissue of biological material well inside the boundary, field strength will further reduce due to dissipation during propagation inside the body. Electric field decreases exponentially with distance from the boundary and are given by (Kumar, V., et al. 2010).

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

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.

Specific absorption rate

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

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) \text{----- (4)}$$

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

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

$$SAR = \frac{\sigma E_z^2}{\rho} \text{----- (5)}$$

Where σ the conductivity of the material and E_z be 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). The amount of heating produced in a living organism depends primarily on the intensity of the radiation once it has penetrated inside the body.

Results

Table 1- Penetrated electric field inside different human tissues at frequency 230 kHz

Tissue of human body	Penetrated electric field (E_z) in (V/m) at frequency (f) = 230 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	7.7316	7.7311	7.7305	7.7301	7.7294
Blood	7.7313	7.7306	7.7298	7.7291	7.7281
Blood vessel	7.7316	7.7309	7.7303	7.7298	7.7291
Body fluid	7.7310	7.7300	7.7288	7.7287	7.7267
Brain white matter	7.7317	7.7314	7.7309	7.7307	7.7301
Cerebella spinal fluid	7.7309	7.7298	7.7285	7.7273	7.7260
Eye sclera	7.7314	7.7308	7.7300	7.7294	7.7286
Fat	7.7319	7.7315	7.7312	7.7311	7.7306
Gall bladder	7.7313	7.7304	7.7295	7.7287	7.7277
Gall bladder Bile	7.7311	7.7300	7.7289	7.7280	7.7268
Gland	7.7314	7.7307	7.7300	7.7294	7.7285
Heart	7.7316	7.7311	7.7306	7.7302	7.7296
Lung outer	7.7316	7.7310	7.7305	7.7300	7.7293
Lung inner	7.7317	7.7313	7.7309	7.7305	7.7300
Lymph	7.7314	7.7307	7.7300	7.7294	7.7285

Mucous membrane	7.7318	7.7314	7.7310	7.7308	7.7302
Muscle	7.7316	7.7309	7.7303	7.7297	7.7291
Pancreas	7.7314	7.7307	7.7300	7.7294	7.7285
Stomach	7.7314	7.7307	7.7300	7.7294	7.7285
Testis	7.7315	7.7308	7.7302	7.7296	7.7290
Vitreous Humor	7.7310	7.7300	7.7288	7.7287	7.7267

Table 2 - Penetrated electric field inside different human tissues at frequency 250 kHz

Tissue of human body	Penetrated electric field (E_z) in (V/m) at frequency (f) = 250 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	7.7315	7.7311	7.7304	7.7300	7.7293
Blood	7.7312	7.7305	7.7296	7.7289	7.7280
Blood vessel	7.7314	7.7309	7.7301	7.7296	7.7289
Body fluid	7.7309	7.7299	7.7287	7.7276	7.7263
Brain white matter	7.7317	7.7314	7.7308	7.7305	7.7300
Cerebella spinal fluid	7.7308	7.7296	7.7282	7.7270	7.7256
Eye sclera	7.7314	7.7307	7.7298	7.7292	7.7284
Fat	7.7317	7.7315	7.7311	7.7309	7.7304
Gall bladder	7.7312	7.7303	7.7293	7.7284	7.7274
Gall bladder Bile	7.7309	7.7300	7.7287	7.7277	7.7265
Gland	7.7313	7.7307	7.7298	7.7292	7.7283
Heart	7.7315	7.7311	7.7305	7.7300	7.7294
Lung outer	7.7315	7.7310	7.7303	7.7298	7.7291
Lung inner	7.7316	7.7313	7.7308	7.7304	7.7299
Lymph	7.7313	7.7307	7.7298	7.7292	7.7283
Mucous membrane	7.7316	7.7314	7.7308	7.7306	7.7300
Muscle	7.7314	7.7309	7.7301	7.7296	7.7289
Pancreas	7.7313	7.7307	7.7298	7.7292	7.7283
Stomach	7.7313	7.7307	7.7298	7.7292	7.7283
Testis	7.7314	7.7308	7.7300	7.7294	7.7287
Vitreous Humor	7.7309	7.7299	7.7287	7.7276	7.7263

Table 3 - Penetrated electric field inside different human tissues at frequency 283.5 kHz

Tissue of human body	Penetrated electric field (E_z) in (V/m) at frequency (f) = 283.5 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	7.7315	7.7309	7.7303	7.7297	7.7292
Blood	7.7312	7.7303	7.7301	7.7286	7.7277
Blood vessel	7.7314	7.7307	7.7301	7.7294	7.7287
Body fluid	7.7308	7.7296	7.7284	7.7272	7.7260
Brain white matter	7.7316	7.7312	7.7308	7.7303	7.7300
Cerebella spinal fluid	7.7307	7.7293	7.7280	7.7266	7.7253
Eye sclera	7.7313	7.7305	7.7297	7.7290	7.7282

Fat	7.7317	7.7314	7.7311	7.7307	7.7304
Gall bladder	7.7311	7.7301	7.7291	7.7282	7.7272
Gall bladder Bile	7.7308	7.7297	7.7285	7.7274	7.7262
Gland	7.7312	7.7305	7.7297	7.7289	7.7281
Heart	7.7315	7.7310	7.7304	7.7299	7.7293
Lung outer	7.7315	7.7308	7.7302	7.7300	7.7290
Lung inner	7.7316	7.7311	7.7307	7.7302	7.7298
Lymph	7.7312	7.7305	7.7297	7.7289	7.7281
Mucous membrane	7.7316	7.7312	7.7308	7.7304	7.7300
Muscle	7.7314	7.7307	7.7301	7.7294	7.7287
Pancreas	7.7312	7.7305	7.7297	7.7289	7.7281
Stomach	7.7312	7.7305	7.7297	7.7289	7.7281
Testis	7.7313	7.7306	7.7299	7.7292	7.7285
Vitreous Humor	7.7308	7.7296	7.7284	7.7272	7.7260

Table 4- SAR in W/kg inside different human tissues at the frequency 230 kHz

Tissue of human body	S.A.R. in (W/kg) at frequency (f) = 230 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	0.0129015	0.0128998	0.0128988	0.0128978	0.0128965
Blood	0.0402143	0.0402140	0.0402037	0.0401964	0.0401860
Blood vessel	0.0184615	0.0184581	0.0184553	0.0184529	0.0184495
Body fluid	0.0887708	0.0887478	0.08872029	0.0887179	0.0886720
Brain white matter	0.00504990	0.00504951	0.00504895	0.00504885	0.00504859
Cerebella spinal fluid	0.118350	0.118316	0.118276	0.118239	0.118200
Eye sclera	0.0308975	0.0307541	0.0307477	0.0307430	0.0307366
Fat	0.00159989	0.00159972	0.00159960	0.00159955	0.00159935
Gall bladder	0.0522381	0.0522259	0.0522137	0.0522029	0.0521894
Gall bladder bile	0.0829493	0.0828258	0.0828022	0.0827829	0.0827572
Gland	0.03103206	0.03102704	0.0310214	0.0310166	0.0310093
Heart	0.0141377	0.0141358	0.0141340	0.0141325	0.0141303
Lung outer	0.0163109	0.0162991	0.0162970	0.0162949	0.0162919
Lung inner	0.0262430	0.0262403	0.0262376	0.0262349	0.0262315
Lymph	0.03103206	0.03102704	0.0310214	0.0310166	0.0310093
Mucous membrane	0.00719425	0.00719421	0.00719346	0.007193094	0.00719197
Muscle	0.0222617	0.0222577	0.0222542	0.0222508	0.0222473
Pancreas	0.03103206	0.03102704	0.0310214	0.0310166	0.0310093
Stomach	0.0308100	0.0308044	0.0307989	0.0307941	0.0307869
Testis	0.026003	0.025998	0.025994	0.025990	0.025986
Vitreous Humor	0.0887708	0.0887478	0.08872029	0.0887179	0.0886720

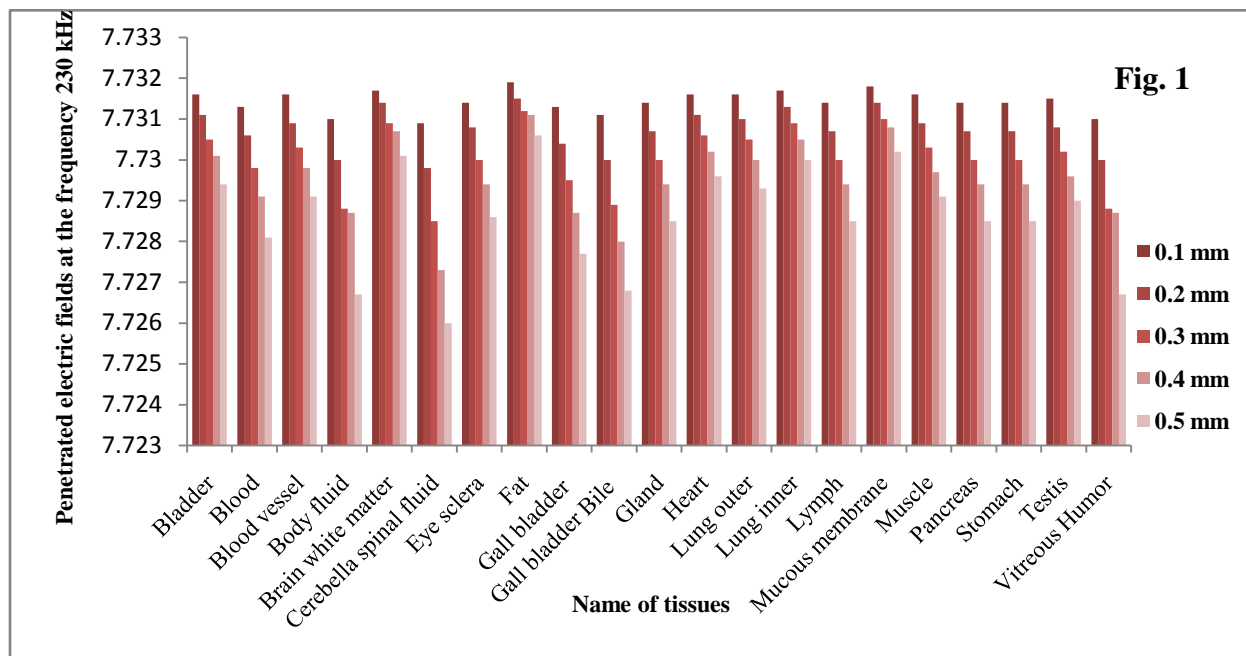
Table 5- SAR in W/kg inside different human tissues at the frequency 250 kHz

Tissue of human body	S.A.R. in (W/kg) at frequency (f) = 250 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	0.0129273	0.0129259	0.0129236	0.0129222	0.0129199
Blood	0.0406133	0.0403288	0.0403194	0.0403121	0.0403027
Blood vessel	0.0184760	0.0184741	0.0184698	0.0184674	0.0184641
Body fluid	0.0887685	0.0887455	0.0887179	0.0886927	0.0886629
Brain white matter	0.00508824	0.00508784	0.00508705	0.00508666	0.00508600
Cerebella spinal fluid	0.118347	0.118310	0.118267	0.118230	0.118187
Eye sclera	0.0308784	0.0308728	0.0308657	0.0308609	0.0308545
Fat	0.00160117	0.00160108	0.00160092	0.00160084	0.00160063
Gall bladder	0.0522373	0.0522251	0.0522111	0.0522062	0.0521860
Gall bladder bile	0.0828450	0.0828258	0.0827979	0.0827765	0.0827508
Gland	0.0311109	0.0311061	0.0310989	0.0310940	0.0310868
Heart	0.0143317	0.0143302	0.0143280	0.0143261	0.0143239
Lung outer	0.0164036	0.0164015	0.0163986	0.0163964	0.0163935
Lung inner	0.0264240	0.0264219	0.0264185	0.0264158	0.0264123
Lymph	0.0311109	0.0311061	0.0310989	0.0310940	0.0310868
Mucous membrane	0.00753887	0.00753848	0.00753731	0.00753692	0.00753535
Muscle	0.0225224	0.0225195	0.0225149	0.0225119	0.0225079
Pancreas	0.0311109	0.0311061	0.0310989	0.0310940	0.0310868
Stomach	0.0308565	0.0308517	0.0308445	0.0308410	0.0308325
Testis	0.0261467	0.0261427	0.0261372	0.0261332	0.0261285
Vitreous Humor	0.0887685	0.0887455	0.0887179	0.0886927	0.0886629

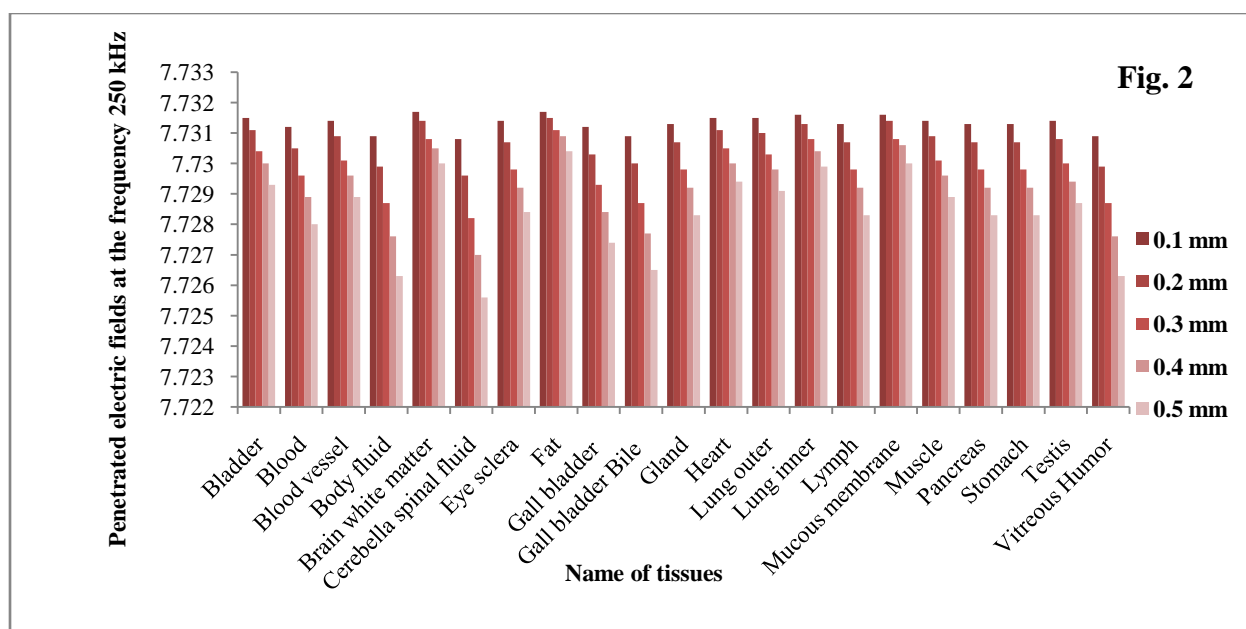
Table 6 - SAR in W/kg inside different human tissues at the frequency 283.5 kHz

Tissue of human body	S.A.R. in (W/kg) at frequency (f) = 283.5 KHz at depth (0.1mm-0.5mm)				
	0.1mm	0.2mm	0.3mm	0.4mm	0.5mm
Bladder	0.012855	0.0128435	0.0128415	0.0128395	0.0128375
Blood	0.0405464	0.0405370	0.0405349	0.0405192	0.0405097
Blood vessel	0.0185002	0.0184968	0.0184940	0.0184906	0.0184873
Body fluid	0.0887662	0.0887386	0.0887111	0.0886835	0.0886560
Brain white matter	0.00514748	0.00514695	0.0054642	0.00514575	0.00514533
Cerebella spinal fluid	0.1183442	0.1183011	0.118261	0.118218	0.118178
Eye sclera	0.0310866	0.0310801	0.0310737	0.0310681	0.0310616
Fat	0.00160315	0.00160319	0.00160306	0.00160290	0.00160277
Gall bladder	0.0522359	0.0522224	0.0522089	0.0521968	0.0521833
Gall bladder bile	0.0828429	0.0828193	0.0827936	0.0827700	0.0827443
Gland	0.0312468	0.0312411	0.0312346	0.0312282	0.0312217
Heart	0.0146387	0.0146368	0.0146345	0.0146327	0.0146304
Lung outer	0.0165670	0.0165640	0.0165615	0.0165606	0.0165563
Lung inner	0.0267114	0.0267079	0.0267051	0.0267017	0.0266989
Lymph	0.0312468	0.0312411	0.0312346	0.0312282	0.0310616
Mucous membrane	0.0080510	0.0080501	0.00804934	0.00804851	0.00804768

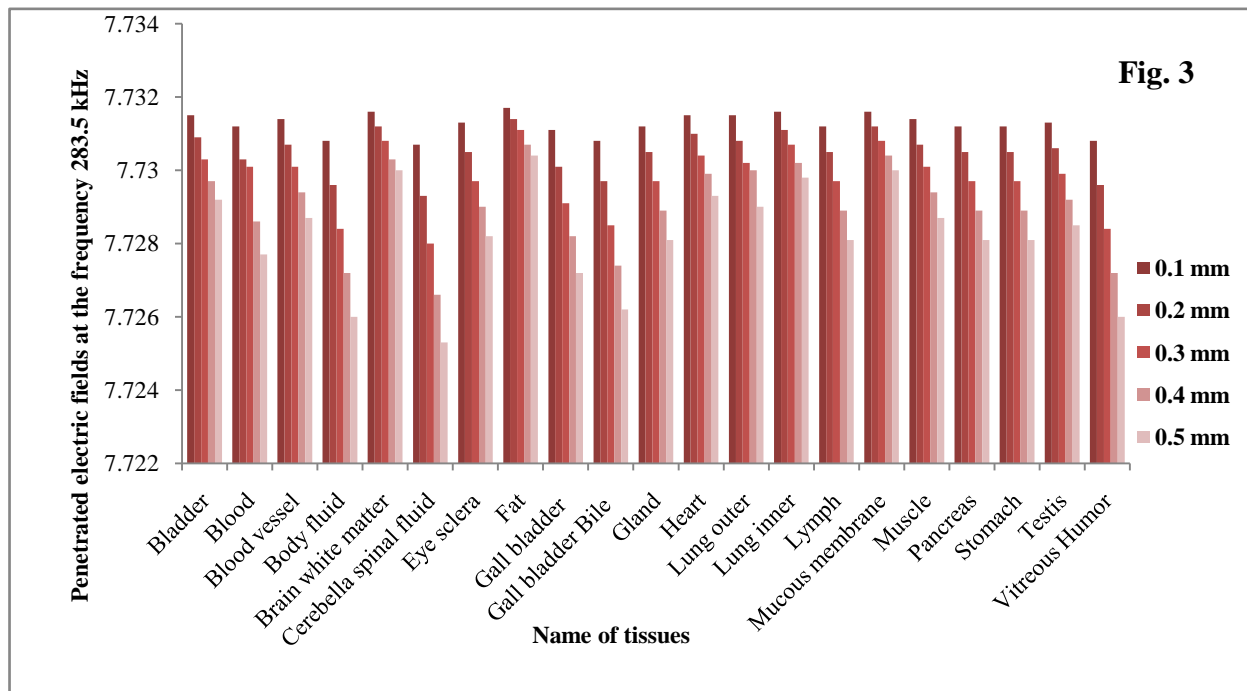
Muscle	0.0229562	0.0229521	0.0229485	0.0229443	0.0229402
Pancreas	0.0312468	0.0312411	0.0312346	0.0312282	0.0310616
Stomach	0.0309371	0.0309315	0.0309251	0.0309187	0.0309123
Testis	0.0263984	0.0263936	0.0263888	0.0263840	0.0263792
Vitreous Humor	0.0887662	0.0887386	0.0887111	0.0886835	0.0886560



For 230 kHz frequency of EMW of radio broadcasting tower the variation of penetrated electric fields with respect to different selected tissues is represented by Fig. 1



For 250 kHz frequency of EMW of radio broadcasting tower the variation of penetrated electric fields with respect to different selected tissues is represented by Fig. 2



For 283.5 kHz frequency of EMW of radio broadcasting tower the variation of penetrated electric fields with respect to different selected tissues is represented by Fig. 3

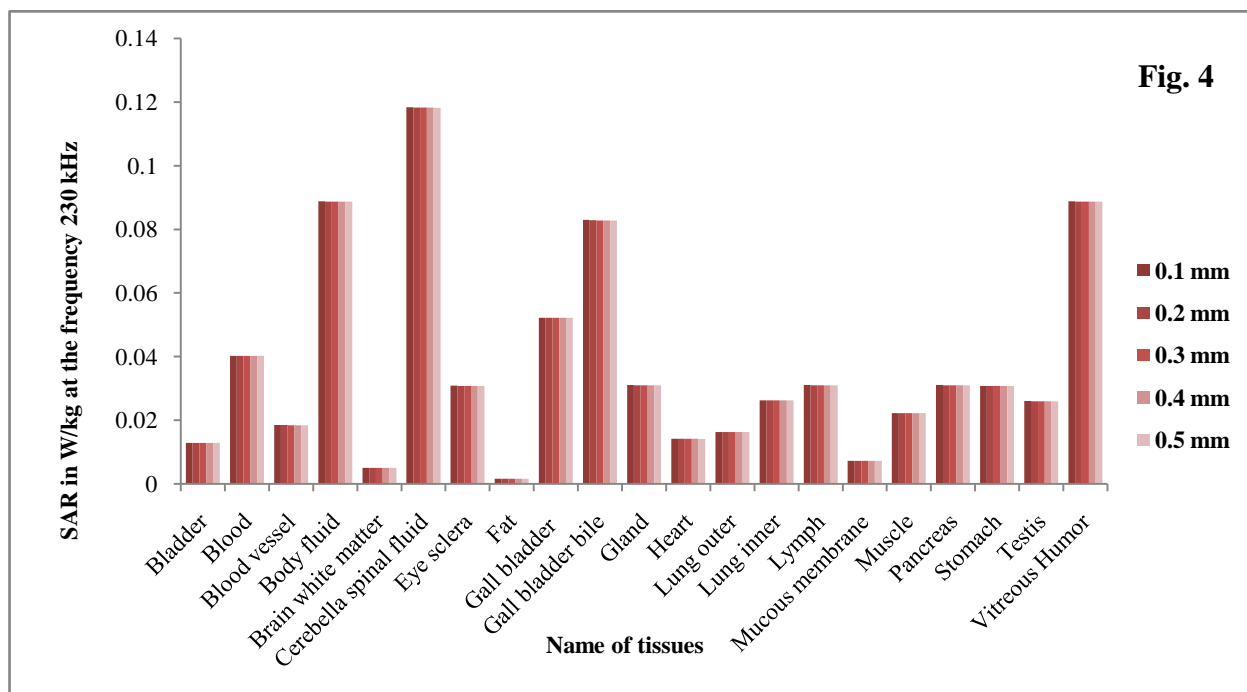


Fig. 4 represents the variation of specific absorption rate (SAR) with respect to different selected tissues of children body due to 230 kHz of electromagnetic wave

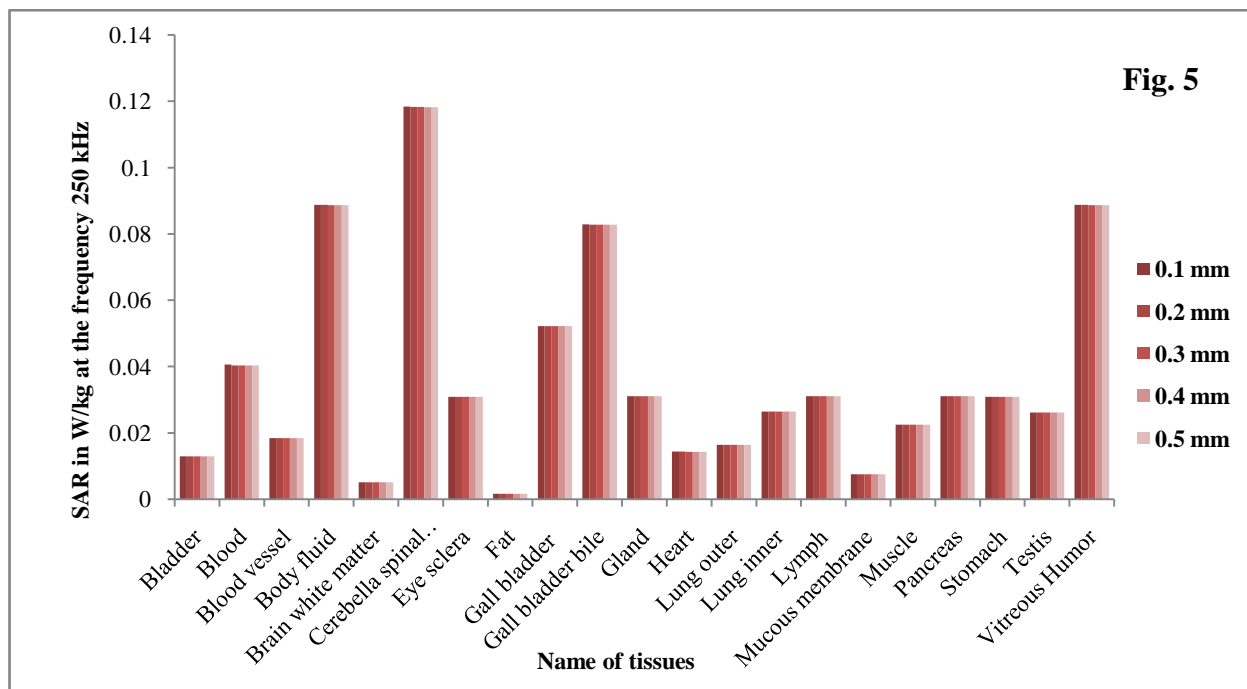


Fig. 5 represents the variation of specific absorption rate (SAR) with respect to different selected tissues of children body due to 250 kHz of electromagnetic wave



Fig. 6 represents the variation of specific absorption rate (SAR) with respect to different selected tissues of body due to 283.5 kHz of electromagnetic wave

Discussion

The electric field and specific absorption rate of the tissues due to the signals of frequency 230 kHz, 250 kHz & 283.5 kHz are taken for this study. These radiations produce an electric blanket around the people. These incident electric fields penetrate inside the children's body. The incident electric fields around the radiators are calculated by Eq. 2. This electric field penetrates inside the children's body and penetrates inside the tissues which are calculated by Eq. (3). The calculated penetrated electric field due to 230, 250 and 283.5 kHz are represented in tables 1, 2 & 3 respectively. The variations of electric field with respect to the different tissues are given in figures 1, 2 and 3 for the frequencies of 230, 250 and 283.5 kHz respectively.

According to ICNIR guidelines, the safe limit of electric field is 6.1V/m (Fact sheet ICNIRP 2010). The data of above given tables 1 and 2 & 3 represent that the induced electric field in selected tissues become greater to the safe limit according to ICNIRP guidelines. When this electric field penetrates inside the tissues, the energy is absorbed by the tissues. Specific absorption rate (SAR) of the selected tissues are calculated by Eq. 5 and represented in table 4, 5 and 6 due to the electromagnetic waves of frequencies 230, 250 and 283.5 kHz respectively. The variation of SAR with respect to selected tissues for 230, 250 and 283.5 kHz are shown in figures 4 & 5 and 6 respectively. These tables also represent that the tissue of the children who are living near at the sea coast radio broadcasting, absorb the given amount of energy. According to some international agencies as WHO, ICNIRP, the specific absorption rate (SAR) becomes harmful after 0.08W/ kg, of the whole body weight. It means that, if SAR becomes greater to 0.08 W/kg. It may be harmful for the tissue life of the children body. The safe limit is taken from ICNIRP guidelines. When the calculated data of SAR which is given in tables 4, 5 and 6 is compared with the safe limit, it is observed that the frequencies of electromagnetic radiation which is taken for this study is harmful for the health of body fluid, cerebella spinal fluid, gall bladder bile, and vitreous humor tissues respectively. The radiator generally situated in populated area and very near to the general public and workers. Thus the given calculations are helpful to till the harmful distance from the tower.

Conclusion

The above calculations and analysis represent that the signals (230 kHz, 250 kHz & 283.5 kHz) of given frequencies are harmful for the tissues of body fluid, cerebella spinal fluid, gall bladder bile and vitreous humor. This study is done only for some selected tissues. Thus if study will be done for some more tissues of the body, it may be possible that harmful effect are found for some more tissues. Thus it is suggested that children and people should keep away from those radiators emitted frequencies of 230 kHz, 250 kHz & 283.5 kHz radiation or we can say that these types of radiators should be located away from the populated area. It is also found by calculation and analysis of this study that 100 m distance from the antenna is harmful for the tissues of the children.

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