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Effect of Cellphone Radiations on Children at Frequency 900 MHz



Abstract: - In this research work the effect of electromagnetic radiation especially radiation from Mobile handsets is studied. The Electric field strength in terms of Volts/ meter is measured using Electromagnetic Radiation Tester. The Penetrated electric field in terms of volts/metre is calculated at depth 'z' for biological tissues such as skin, Blood, muscle and bone. In this paper we have covered measurements of electric field strength of EM radiation from mobile handsets and the results are compared with the standards of ICNIRP, FCC, WHO and DoT. In addition we have made survey of 300 children residing within the vicinity of mobile tower to understand the impact of EM radiation. Since the children have small size head, delicate bones, thin skin and if exposed to radiations beyond the standard limits may cause harm in long run.

Keywords: ICNIRP, Field Strength, Power Density

I. Introduction

The shifting of ordinary India into digital India has motivated Indian citizens towards the era of cashless transactions 24 X 7. This has enabled the present telecom system to install more number of towers to cater the services to the cell phone users. There is barely any citizen deprived of mobile handset. The ordinary layman also uses the push button handset if not the smart phone. The technologies used are right from first generation to the present 5th generation. The mobile operators provide services from their towers to all technologies.

The present paper discusses about the impact of EM radiations on children. The measurement of electric field strength, radiated from the branded mobile handsets, the penetrated electric field induced in biological tissues is calculated and result is compared with the standards of ICNIRP, FCC,WHO and DoT. In support of this a standard survey of 300 children, who are residing in the vicinity of active mobile towers is done and is analyzed through the standard statistical test. The result obtained is discussed accordingly.

II. Parameters Associated with RF EMF Radiation

According to the guidelines of ICNIRP the parameters associated with radiation are Absorbed energy density, Incident energy density, Plane-wave equivalent incident energy density, Absorbed power density, Incident power density, Plane-wave equivalent incident power density, Induced electric field strength, Incident electric field strength, Incident electric field strength, Incident magnetic field strength, and Specific energy absorption rate SAR. For any system the safe radiation limits are advised to follow as per the values of these parameters for specific frequency and the duration of exposure. In the present work, the Incident electric Field is measured using the Electromagnetic Radiation Tester and Penetrated Electric Field is calculated for biological tissue, "skin" for the purpose of study in this paper.

III. Determination of Penetrated Electric Field

There are two conditions used under which, the electric field induced due to the electric radiated by handset that is, penetrated electric field E_{ind} is calculated,

1. Considering Mobile phone handset as a point source radiating EM wave at frequencies 900 MHz respectively at a distance from 1 to 15 cm.

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2.It is assumed that, the radiated electric field penetrates into the children body and causes Penetrated Electric field in V/m at the depth 'z' from 0.1 to 0.5 mm for the Tissue 'skin' .

Measurement of Incident electric field

The electric field is measured using standard Electromagnetic Radiation Tester shown below,



The standard mobile phone handsets are taken for the purpose of study. The handset belongs to all the generations. The handset ranges from basic push button handset to smart phones. Accordingly depending on the operating frequencies 900 MHz, 1800Mhz, 2100MHz and 2450MHz are used for measurement and calculation purpose.

The present handset under study named as Handset 1, The corresponding incident electric field at a distance from 1 cm to 15 cm is shown in Table 1 and the corresponding graphical response is shown in Fig.1,

Table No.1 Measurement of Electric Field strength in V/m for Handset1

'r' in Cm from Handset	Handset 1	
	Eind in Idle State	Eind During call in progress
1	07	201
2	00	193
3	00	162
4	00	140
5	00	132
6	00	101
7	00	93
8	00	79
9	00	48
10	00	32
11	00	21
12	00	13
13	00	05
14	00	05
15	00	03

Table 1 shows that, incident electric field in V/m for different handsets, when an handset is moved at a distance , 'r' from 1 Cm to 15 Cm. Incident electric field is measured at idle state and measured during call in progress.

From Table 1,it appears that, there is change in the incident electric field with respect to the variation in the distance of mobile handset 1. The incident electric field is more near mobile handset,when the EMF tester is moved towards it.The incident electric fields during Mobile handset at idle state and during call in progress are shown in table 1.

Calculation of Penetrated Electric Field

In the course of electromagnetic wave propagation inside the tissue of any biological material, the corresponding field will further reduce as dissipation occurs, then the electric field decreases exponentially with distance from boundary and given by equation no.1 and the calculation of Penetrated Electric field can be done depending upon the skin depth obtained by considering dielectric parameters, the dielectric parameters taken into account for calculation of skin depth. The dielectric parameters are based on the Gabriel dispersion relationships at frequency 900 MHz.

$$E_z = E_o e^{-\left(\frac{z}{\delta}\right)} \dots\dots\dots(1)$$

E_o is the magnitude of field inside the boundry ,here we term it as incident electric field, measured by the standard field strength meter in V/m, E_z is the field inside the depth , 'z', here we refer it to penetrating electric field and δ is the skin depth.

The skin depth for biological material is given by,

$$\delta = \left(\frac{1}{\omega q}\right)^2 \dots\dots\dots(2)$$

$$q = \left[\frac{\epsilon \mu}{2} \{(1 + P^2)^{1/2} - 1\}\right]^{1/2} \dots\dots\dots(3)$$

Where, P is the ratio of conduction current to the displacement current and is,

$$P = \frac{\sigma}{\omega \epsilon} \dots\dots\dots(4)$$

here ε is permittivity of, is angular frequency of radiation, σ is conductivity of biological material and μ is permeability of materials of tissues and are obtained from database as per Gabriel compilation for dielectrics.

Calculations of induced i.e Penetrated electric field for handset 1:

For biological tissue , the Skin, the Permittivity is = 41.405194249801646, and Elec. Cond. (S/m) is σ=0.866759327096543 And at f= 900MHz and E_o =201 V/m at distance 1 Cm from mobile handset. The penetrated electric field at depth z=0.1mm to z=0,5mm is calculated using above equations and the corresponding result is shown in Table 2.

Table No.2 Calculation of Penetrated Electric Field at depth “z” inside the tissue Skin due to Handset 1

Distance in cm from handset	Penetrated Electric Field in V/m inside the Skin at depth in mm				
	0.1	0.2	0.3	0.4	0.5
1	199.6508	198.3107	196.9795	195.6573	194.344
2	191.7045	190.4177	189.1395	187.87	186.6089
3	160.9126	159.8325	158.7596	157.6939	156.6354
4	139.0603	138.1268	137.1997	136.2787	135.364
5	131.114	130.2339	129.3597	128.4914	127.6289
6	100.322	99.64864	98.97976	98.31536	97.65543
7	92.37574	91.75568	91.13978	90.52801	89.92034
8	78.46972	77.943	77.41981	76.90014	76.38395
9	47.6778	47.35777	47.03988	46.72413	46.4105
10	31.7852	31.57185	31.35992	31.14942	30.94033

11	20.85904	20.71902	20.57995	20.44181	20.30459
12	12.91274	12.82606	12.73997	12.65445	12.56951
13	4.966438	4.933101	4.899988	4.867097	4.834427
14	4.966438	4.933101	4.899988	4.867097	4.834427
15	2.979863	2.959861	2.939993	2.920258	2.900656

The table 2 shows the penetrated electric field inside the skin due to the electromagnetic wave at frequency 900MHz of mobile phone handset at depth, ‘z’ varying from 0.1 mm to 0.5 mm inside the body under consideration from ‘r’ which varies from 1 cm to 15 cm from the mobile phone. The values shown in bold represents that , the value of penetrating electric field is beyond the permissible range of ICNIRP standards. The distance of mobile handset beyond 8cms is the safe limits as per ICNIRP standards.

IV. Calculation of Specific Absorption Rate(SAR)

Dielectric properties of biological tissues or organs are generally considered as dielectric lossy material and magnetically transparent because the relative magnetic permeability (μ) is 1. Therefore, the SAR is usually derived from the following equation,

$$SAR = \frac{\sigma E_i^2}{\rho} \dots\dots\dots(5)$$

Where, Ez, is the field inside that material, σ is (S/m) the conductivity of the material, ε is permittivity of human tissue and Ei is the internal electric- field.

For handset 1,

Specific Absorption Rate (SAR) at depth z= 0.1 to z=0,5mm, the penetrating electric field is Ez, the permittivity of human tissue is 0.866759327096543 and the conductivity is, 41.405194249801646, is shown in Table 3 as below,

Table No.3 Calculation of Specific Absorption Rate(SAR) inside the tissue-skin due to Handset 1,

Distance in Cm from handset	SAR Specific Absorption rate in W/Kg inside the tissue -Skin at depth z= 0.1 to 0.5 mm				
	0.1	0.2	0.3	0.4	0.5
1	834.4221	823.2581	812.2426	801.375	790.6531
2	769.3223	759.0289	748.873	738.8539	728.9679
3	542.0306	534.7784	527.623	520.5632	513.5983
4	404.8089	399.3922	394.0488	388.7762	383.5748
5	359.8668	355.0519	350.3013	345.6144	340.9901
6	210.6862	207.8674	205.0862	202.3422	199.6349
7	178.6321	176.2421	173.884	171.5575	169.262
8	128.8985	127.1739	125.4723	123.7935	122.1372
9	47.58566	46.94898	46.32081	45.70105	45.08958
10	21.14918	20.86622	20.58702	20.31158	20.03981
11	9.108195	8.986325	8.866094	8.747469	8.630424
12	3.490443	3.443739	3.397665	3.352203	3.307352
13	0.516338	0.509429	0.502613	0.495888	0.489253
14	0.516338	0.509429	0.502613	0.495888	0.489253
15	0.185882	0.183395	0.180941	0.17852	0.176131

According to the guidelines of ICNIRP 1998, For Frequency ranging from 400–2,000 MHz Induced EF is 1.375f^{0.5} and for f=900MHz Eind is 41.250 V/m is safe. And as per the revised guidelines of ICNIRP March 2020 ,the safe limit for exposure for Induced Electric field for 400–2,000 MHz >400 – 2000 MHz 4.72fM^{0.43}. Eind is 33.440 V/m.

For the frequency of Electromagnetic Magnetic Wave ranging from 10 MHz–10 GHz its safe limit for SAR is 0.4 W/kg as per ICNIRP.

From the values of electric field from table 1 and table 2 ,it is observed that, the mobile phone handset radiates power and Penetrates an electric field, which is within safe limits upto certain distance as per ICNIRP standards .The computed values of SAR increases if the mobile handset is moved form 15 cm to 1 cm .And fall in the safe limits as prescribed by ICNIRP guidelines beyond 14 cms.

V. Understanding the impact of EM radiations on Children

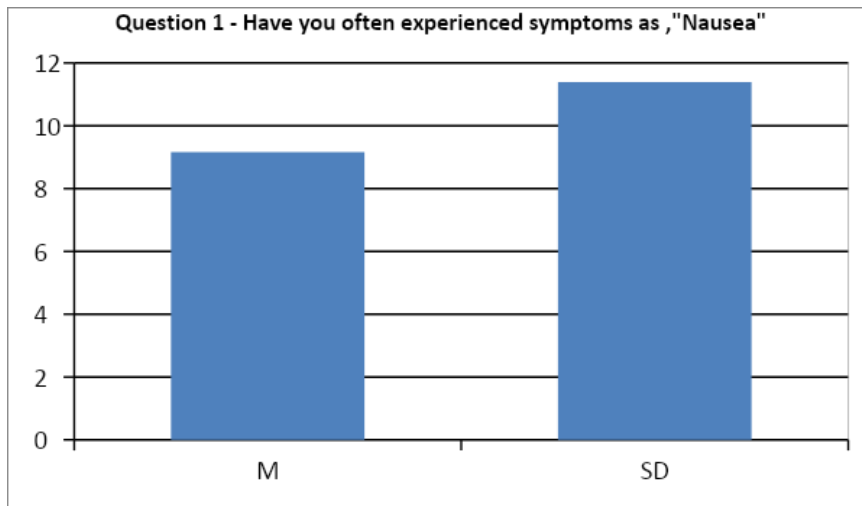
We have got responses from 300 heterogeneous samples within the age group of 7-13 . These children fulfill the condition of their residence located within 300 meters from the active mobile towers. The impact of EM on for the symptom Nausea and Loss of Appetite is analyzed through questionnaire and its results are computed using SPSS software and analyzed through Chi square test of statistics .

Table No.4 Question - 1- Have you often experienced symptoms as ,"Nausea"

N	M	SD	X ² Test
300	9.16	11.39754	5.022

Significant Level .05%

Ref. by SPSS Software



Interpretation: Table 4 depicts the following facts regarding Electromagnetic Radiation effect on children aged below 7-13 years.

1. Mean score of the Children aged below 7-13 years is 9.16 with standard deviation of 11.39754.
2. X²-test was used at 0.05 level of significance. The obtained **Chi-Square result is 5.022** at **1** degree of freedom was found greater than the **book value of 3.84**. Further this confirms that there exists significant difference between pre-test and post test scores of maximum test conducted on the children of age below 14 years at 0.05 level of significance.

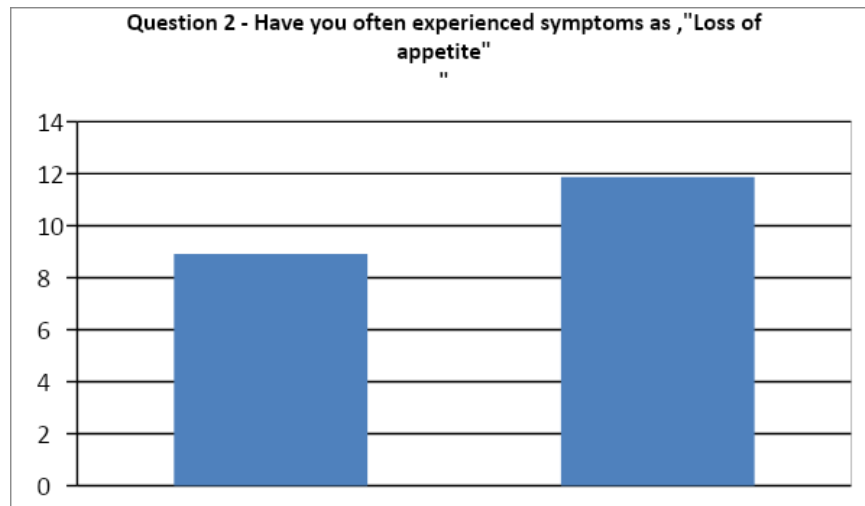
Based on the above analysis and test result chi square test result the null hypothesis is not accepted i.e. there is significant effect on children in the age group of 7-13 years. Opinion of Indian physicians was done with respect to the technical aspect of, “nausea”. It is revealed that, apart from general reasons, there is increased complain among current clients. On general enquiry it appears that, they are residing in the close vicinity of active mobile towers.

Table No. 5 Question - 2- Have you often experienced symptoms as ,"Loss of appetite"

N	M	SD	X ² Test
300	8.91	11.87457	7.099

Significant Level .05%

Ref. by SPSS Software



Interpretation: Table 5 depicts the following facts regarding Electromagnetic Radiation effect on children aged below 7-13 years.

1. Mean score of the Children aged below 7-13 years is 8.91 with standard deviation of 11.87457.
2. χ^2 -test was used at 0.05 level of significance. The obtained **Chi-Square result is 7.099** at **1** degree of freedom was found greater than the **book value of 3.84**. Further this confirms that there exists significant difference between pre-test and post test scores of maximum test conducted on the children of age below 14 years at 0.05 level of significance.

Based on the above analysis and test result chi square test result the null hypothesis is not accepted i.e. there is significant effect on children in the age group of 7-13 years. Opinion of Indian physicians was done with respect to the technical aspect of, "Loss of appetite". It is revealed that, apart from general reasons, there is increased complain among current clients. On general enquiry it appears that, they are residing in the close vicinity of active mobile towers.

VI. Conclusion

- The penetrating electric field is more as we go closer to the mobile phone handset. There is variation in Penetrating electric field at center frequency 900 Mhz. The penetrating electric field values at skin depth of 0.1 to 0.5 mm for the tissues Skin, is beyond the admissible limit recommended by ICNIRP. Hence the live entities using mobile phone handsets may have to face health consequences.
- The SAR value increases as we move towards the mobile phone handset . There is variation in SAR in W/kg at the center frequency 900 Mhz. The SAR values at skin depth of 0.1 to 0.5 mm for the tissue Skin, is beyond the admissible limit recommended by ICNIRP. Hence the live entities using mobile phone handset may have to face health consequences.
- While going through the statistical results obtained for the effect of EM radiations on children and on the basis of analysis and test result of chi square test result, the null hypothesis is not accepted i.e. there is significant effect on the health of children in the age group of 7-13 years for all the fifteen questions under study. The opinions of the Physicians with whom we consulted and took opinion have expressed their view in support of the rejected hypothesis. They rely on the ,the guidelines of WHO to follow the ICNIRP recommendations. The obtained Chi-Square result for all the questions under consideration regarding health issue at 1 degree of freedom was found greater than the book value of 3.84 at at 0.05 level of significance. This suggests that, there is effect of Electromagnetic Radiations on Children.

From the experimental results based on the observations ,if compared with ICNIRP guidelines , IEEE, NCRP, ARPANSA, DOT Guidelines, certainly the values obtained are alarming. The increased number of towers and increased number of mobile phone handsets in families has increased the risk of health with hidden symptoms, particularly on children who has to live life more than present adults.

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