

Harmful effects of 41 and 202 MHz radiations on some body parts and tissues

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Many types of invisible electromagnetic waves are produced in our atmosphere. When these radiations penetrate our body, electric fields are induced inside the body, resulting in the absorption of power, which is different for different body parts and also depends on the frequency of radiations. Higher power absorption may result into health problems. In this communication, effects of electromagnetic waves (EMW) of 41 and 202 MHz frequencies transmitted by the TV tower have been studied on skin, muscles, bone and fat of human. Using international standards for safe exposure limits of specific absorption rate (SAR), we have found the safe distance from TV transmission towers for two frequencies. It is suggested that transmission towers should be located away from the thickly populated areas and people should keep away from the transmission towers, as they radiate electromagnetic radiations that are harmful to some parts/tissues of body.

Keywords: Induced electric field, Specific absorption rate, Electromagnetic wave, Human body

Interaction of electromagnetic waves (EMW) with biological tissues is a complex function of numerous parameters. EMWs in free space are characterized by the frequency, intensity of electric and magnetic fields, their direction of propagation and polarization. Higher frequencies EMWs produce fields of varying intensity at various places. Main sources of higher frequency fields are communication systems i. e. Radio, TV, microwave transmission and mobile phone towers. High intensity fields exist near these towers and may affect people living around these towers. Also, prolonged use of mobile phones affects the people because of field's concentration and resonance in the vicinity of human brain. Earlier studies on the effects of EMWs on the human body have shown that long time high frequency exposure is very harmful for the human body¹⁻⁸. EMW is known to affect the human health directly. According to fact sheet No. 201, July 1998 of World Health Organization (WHO), EMWs may cause spontaneous abortion (miscarriage) or birth of deformed children. Also, radiation from video display units (VDU) screens has been identified as a source of eyestrain and headaches. The people living near the transmitting antennas of radio, TV and mobile phone

towers situated near the thickly populated areas are exposed to varying intensities of EMW emitted by these antennas. In large cities, the average background of radio frequency level is about $50 \mu\text{W}/\text{m}^2$, but it increases very rapidly on moving towards the transmission tower. The domestic equipments such as microwave ovens, TV and other VDUs, refrigerator, mixer, hair dryer, vacuum cleaner, coffee machine etc. also produce radiations, but of low frequency. In this communication, effects of electromagnetic waves (EMW) of 41 and 202 MHz frequencies transmitted by the TV tower have been studied on skin, muscles, bone and fat of human beings.

Methodology

We evaluated specific absorption rate (SAR) values for two frequencies of 41 and 202 MHz as used by TV transmitters of Haridwar and Varanasi, respectively. The SAR values were evaluated for different distances from tower and for different depths inside the body. The variation was also calculated for different types of tissues of different body parts, having varying values of conductivity, permittivity and mass density.

The induced electric field inside the human body can be quantified in various ways. A dosimetry measure that has been widely adopted, is the specific absorption rate (SAR) defined as 'the rate of energy absorbed per unit mass'. In terms of the energy

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absorbed dW in the mass element dm in time dt , SAR is given as¹¹:

$$\text{SAR} = d/dt (dW/dm) \quad \dots (1)$$

If volume of element is dV and ρ is the density of element, $dm = \rho dV$, hence

$$\text{SAR} = d/dt (dw/\rho dV) \quad \dots (2)$$

By using Poynting vector theorem for sinusoidal electromagnetic field, we get:

$$\text{SAR} = \sigma E_i^2 / \rho \quad \dots (3)$$

where σ is conductivity and ρ the mass density of the body material and E_i is the electric field inside that material. The value of the field inside the body at a depth z is calculated from the equation⁷:

$$E = E_0 \exp(-z/\delta) \quad \dots (4)$$

where δ is the skin depth for the field as given by Kumar⁸. E_0 is the field present to which a human body is exposed. Its value is inversely proportional to the distance from the tower and can be calculated for a transmitter of power P by the equation⁷.

$$E_0 = 7.746\sqrt{P/r} \quad \dots (5)$$

Dielectric behavior of biological materials

The dielectric behavior of fat and bone is quantitatively similar to muscles and skin, but the values of conductivity (σ) and dielectric constant (ϵ) are different and vary with the frequency of radiation. The main difference in these biological materials is of water content. Bone and fat have low water content tissues, while muscles and skin have high water content tissues. The values of dielectric constant and conductivity also vary with frequency of radiation and from one type of tissue to another. The variation in conductivity and permittivity in biological materials is given by Johnson & Guy¹².

Guidelines for limiting exposure of EMF

According to International Non-ionizing Radiation Protection (INIRP), International Non-ionizing Radiation Committee (INIRC) and WHO, exposure of

general public should be kept below a whole body SAR of 0.08 W/kg¹³ and if SAR becomes more than 0.08 W/kg, it becomes harmful for skin, muscles, bone and fat.

Results and Discussion

In the present study, EMWs of frequencies 41 and 202 MHz are taken, which are transmitted by TV transmission towers. When a transmission tower starts functioning, it radiates EMW and the electric fields propagate around the tower, the strength of which vary with the distance as shown in Table 1. When a human body is exposed to these fields, they penetrate inside the body and during propagation of inside the body, there is a reduction in the field values due to the absorption of electromagnetic energy of EMW by the body.

Table 2 shows penetrated electric field inside the fat and bone and Table 3 inside skin and muscle when exposed to 41 MHz and 202 MHz radiations. SAR is calculated from Eq. 3 and SAR values of skeletal muscles, bone cortical, fat and bone spongy are shown in Tables 4, 5, 6 and 7, respectively.

Calculated SAR values above the safe limit are shown as bold face in the Tables. Table 4 shows that 41 MHz and 202 MHz are harmful for human health even at a distance of 100 m or more from the tower, as the SAR values are more than safe limit for skeletal muscles even up to 5 mm depth inside the muscles. Similarly, for bone cortical 41 MHz and 202 MHz radiations are harmful within the range of 1 m and 10 m from the tower respectively (Table 5). Table 6 shows that fat of human body is safe for both radiations even at 1 m from the tower. Table 7 shows that for bone spongy 41 and 202 MHz radiations are harmful within the range of 1 m and 10 m from the tower, respectively. The values of Tables 4 to 7 show that 202 MHz radiations are more harmful in comparison with 41 MHz.

When high frequency EMW is incident on the human beings, the different parts of the body absorb the energy of radiation. When this absorbed energy becomes greater to a particular safe limit, it becomes harmful for human health. According to fact sheet no. 183 of WHO, exposure of high frequency EMW increases the incidence of cancer in mice at a distance of 0.65 m from the transmission tower, while in the

Table 1—Induced electric field at different distances from the tower of power 1 kW

Distance from the tower (m)	1	10	20	30	40	50	60	70	80	90	100
Electric field (V/m)	774.6	77.46	38.73	25.82	19.365	15.492	12.91	11.065	9.68	8.6	7.746

Table 2—Penetrated electric field inside the fat and bone when 41 and 202 MHz EMW incident on the human beings

(a) When exposed to 41 MHz EMW

Distance from the tower (m)	Incident electric field (V/m)	Penetrated electric field (V/m) inside the fat and bone at the depth (mm)				
		1	2	3	4	5
1	774.6	773.29	773.28	772.58	771.96	771.26
10	77.46	77.32	77.32	77.25	77.19	77.12
20	38.73	38.695	38.664	38.629	38.59	38.56
30	25.82	25.79	25.77	25.75	25.73	25.7
40	19.365	19.34	19.33	19.31	19.29	19.28
50	15.492	15.47	15.46	15.45	15.43	15.42
60	12.91	12.89	12.88	12.87	12.86	12.85
70	11.065	11.055	11.046	11.036	11.027	11.017
80	9.68	9.67	9.66	9.65	9.64	9.63
90	8.6	8.59	8.58	8.577	8.57	8.56
100	7.746	7.739	7.732	7.725	7.719	7.712

(b) When exposed to 202 MHz EMW

1	774.6	772.58	770.64	768.63	766.69	764.76
10	77.46	77.25	77.06	76.86	76.66	76.47
20	38.73	38.62	38.53	38.43	38.33	38.23
30	25.82	25.75	25.68	25.62	25.55	25.49
40	19.365	19.31	19.26	19.21	19.16	19.11
50	15.492	15.45	15.41	15.37	15.33	15.29
60	12.91	12.87	12.84	12.81	12.77	12.74
70	11.065	11.03	11.008	10.979	10.952	10.924
80	9.68	9.65	9.63	9.6	9.58	9.55
90	8.6	8.57	8.55	8.53	8.512	8.49
100	7.746	7.725	7.7	7.68	7.66	7.64

Table 3—Penetrated electric field inside the skin and muscle when 41 and 202 MHz EMW incident on the human beings

(a) When exposed to 41 MHz EMW

Distance from the tower (m)	Incident electric field (V/m)	Penetrated electric field (V/m) inside the skin and muscle at the depth (mm)				
		1	2	3	4	5
1	774.6	767.7	760.88	754.07	747.41	740.75
10	77.46	76.77	76.08	75.4	74.74	74.07
20	38.73	38.38	38.044	38.04	37.37	37.03
30	25.82	25.59	25.36	25.13	24.9	24.69
40	19.365	19.19	19.02	18.85	18.68	18.51
50	15.492	15.35	15.21	15.08	14.94	14.81
60	12.91	12.79	12.568	12.567	12.456	12.34
70	11.065	10.966	10.869	10.77	10.67	10.58
80	9.68	9.59	9.5	9.42	9.25	9.04
90	8.6	8.52	8.44	8.37	8.29	8.22
100	7.746	7.67	7.6	7.54	7.47	7.4

(b) When exposed to 202 MHz EMW

1	774.6	758.56	742.91	727.5	712.47	697.75
10	77.46	75.85	74.29	72.27	71.24	69.77
20	38.73	37.8	37.14	36.37	35.6	34.88
30	25.82	25.28	24.76	24.25	23.74	23.25
40	19.365	18.96	18.57	18.18	17.81	17.44
50	15.492	15.17	14.85	14.55	14.24	13.95
60	12.91	12.64	12.38	12.12	11.87	11.62
70	11.065	10.83	10.61	10.39	10.17	9.96
80	9.68	9.47	9.28	9.09	8.9	8.7
90	8.6	8.42	8.24	8.07	7.9	7.7
100	7.746	7.5	7.4	7.2	7.1	6.9

Table 4—Specific absorption rate (SAR) by the skeletal muscle when 41 and 202 MHz EMW incident on the human beings

(a) *When exposed to 41 MHz EMW*

Distance from the tower (m)	SAR (W/kg) inside the skeletal muscle at the depth (mm)				
	1	2	3	4	5
1	2917.34	2865.7	2814.6	2765.1	2716.1
10	29.73	28.65	28.14	27.65	27.16
20	7.29	7.164	7.162	6.912	6.787
30	3.24	3.18	3.12	3.07	3.01
40	1.822	1.79	1.75	1.72	1.69
50	1.16	1.46	1.12	1.1	1.08
60	0.81	0.7818	0.781	0.768	0.754
70	0.595	0.584	0.574	0.564	0.554
80	0.455	0.447	0.439	0.404	0.424
90	0.359	0.353	0.346	0.34	0.33
100	0.29	0.286	0.281	0.276	0.27

(b) *When exposed to 202 MHz EMW*

1	5259.2	5004.5	4837.4	4639.5	4449.8
10	52.59	50.04	48.37	46.39	44.49
20	13.06	12.61	12.09	11.59	11.12
30	5.84	5.6	5.37	5.15	4.94
40	3.28	3.15	3.023	2.89	2.78
50	2.1	2.01	1.93	1.85	1.77
60	1.46	1.4	1.34	1.28	1.23
70	1.07	1.02	0.987	0.94	0.9
80	0.82	0.787	0.755	0.724	0.69
90	0.647	0.621	0.59	0.57	0.54
100	0.525	0.504	0.48	0.46	0.444

Calculated SAR values, above the safe limit are shown as bold face in the Table

Table 5—SAR by the bone cortical when 41 MHz EMW incident on the human beings

(a) *When exposed to 41 MHz EMW*

Distance from the tower (m)	SAR (W/kg) inside the bone cortical at the depth (mm)				
	1	2	3	4	5
1	5.4415	5.4414	5.4316	5.4228	5.4138
10	.054415	.0544	.05431	.05422	.05413
20	.01362	.013579	.01355	.01353	.0135
30	.006055	.00604	.00603	.00602	.00601
40	.003406	.0034	.00339	.003389	.003382
50	.00218	.002176	.002172	.002169	.002165
60	1.512	.001511	.001508	.001506	.001503
70	.001112	.00111	.001108	.001106	.001104
80	0.00085	0.00084	0.00084	0.00084	0.00084
90	0.00067	0.00066	0.00066	0.00066	0.00066
100	0.00054	0.00054	0.00054	0.00054	0.00054

(b) *When exposed to 202 MHz EMW*

1	12.117	12.056	11.993	11.933	11.873
10	0.1212	0.1205	0.1199	0.119	0.119
20	.0303	.0301	.02999	.0298	.0297
30	.0135	.0134	.0133	.01326	.01319
40	.0076	.0075	.00749	.00746	.00742
50	.00484	.0048	.00479	.00477	.00474
60	.0034	.00334	.00333	.00331	.00329
70	.00247	.00245	.00244	.00243	.00242
80	.00189	.00188	.00187	.00186	.00185
90	.00149	.00148	.001475	.00147	.00146
100	.00121	.00120	.001199	.00119	.00118

Calculated SAR values, above the safe limit are shown as bold face in the Table

Table 6—SAR by fat when 41 and 202 MHz EMW incident on the human beings

(a) When exposed to 41 MHz EMW

Distance from the tower (m)	SAR (W/kg) inside the fat at the depth (mm)				
	1	2	3	4	5
1	.010345	.010344	.010326	.010309	.010291
10	0.000103	0.0001024	0.000132	0.000103	0.0001029
20	0.0000259	0.0000256	0.0000258	0.00002576	0.0000257
30	0.00001152	0.0000115	0.00001147	0.00001145	0.00001143
40	0.00000647	0.00000646	0.00000645	0.00000644	0.00000643
50	0.00000414	0.000004137	0.00000413	0.00000412	0.00000411
60	0.00000287	0.000002869	0.000002868	0.000002863	0.00000285
70	0.000002114	0.00000211	0.000002107	.0000022103	0.00000209
80	0.000001617	0.000001614	0.000001612	0.00000161	0.000001607
90	0.000001276	0.000001273	0.000001272	0.00000127	0.00000126
100	0.000001036	0.000001034	0.000001032	0.00000103	0.000001028

(b) When exposed to 202 MHz EMW

1	.023099	.022983	.022863	.022748	.022633
10	0.00023099	0.0003298	0.0002286	0.0002274	0.0002263
20	0.00005774	0.00005745	0.00005715	0.00005685	0.00005658
30	0.00002566	0.00002553	0.0000254	0.000025275	0.000025148
40	0.00001443	0.00001436	0.000014288	0.000014217	0.000014146
50	0.00000923	0.00000919	0.00000914	0.00000909	0.00000905
60	0.00000641	0.000006384	0.00000635	0.000006318	0.00000628
70	0.000004713	0.000004689	0.00000466	0.00000464	0.00000461
80	0.000003606	0.00000358	0.00000357	0.00000355	0.00000353
90	0.000002846	0.000002833	0.00000281	0.0000028	0.000002789
100	0.0000023	0.00000229	0.000002286	0.000002274	0.000002263

Table 7—SAR by bone spongy when 41 and 202 MHz EMW incident on the human beings

(a) When exposed to 41 MHz EMW

Distance from the tower (m)	SAR (W/kg) inside the bone spongy at the depth (mm)				
	1	2	3	4	5
1	7.82154	7.82134	7.80718	7.79466	7.78071
10	.078215	.078213	.078071	.077946	.077807
20	.019584	.019553	.019517	.019478	.019448
30	.008703	.00869	.008674	.008659	.008644
40	.004895	.004888	.004879	.004871	.004862
50	.003133	.003128	.003122	.003117	.003112
60	.002174	.002172	.002168	.002165	.002161
70	.001598	.001595	.001593	.00159	.001587
80	.001223	.00122	.001219	.001217	.001215
90	0.0009651	0.0009629	0.0009622	0.0009606	0.000959
100	0.00078215	0.00078213	0.0007807	0.0007794	0.000778

(b) When exposed to 202 MHz EMW

1	17.36947	17.28248	17.19204	17.10577	17.01936
10	.17369	.17282	.17192	.17105	.17019
20	.043423	.0432	.042976	.04275	.042548
30	.019364	.019334	.019298	.019265	.019232
40	.010892	.010875	.010855	.010838	.010818
50	.006971	.006912	.006876	.006841	.006807
60	.00482	.0048	.004775	.004751	.004727
70	.00354	.003526	.003507	.00349	.003472
80	.002712	.002698	.002684	.002671	.002657
90	.00214	.00213	.002118	.002108	.002097
100	.00173	.00172	.001719	.00171	.0017

Calculated SAR values, above the safe limit are shown as bold face in the Table

present study, 41 MHz radiations are found to be harmful for bone cortical and bone spongy within the range of 1 m from the tower. Due to SAR of EMW, the temperature of tissue or cell of biomaterial is increased. After a limit, it becomes harmful for the cell or tissue life. According to fact sheet no. 182, reviewed in May 1998, fields at frequencies above 1 MHz primarily cause heating by moving ions and water molecules through the medium in which they exist. Even very low levels of energy produce a small amount of heat, but the body's normal thermoregulatory processes carry this heat away without the person noticing it. Some studies show that exposure to fields cause heating and may have adverse health consequences, including cancer and memory loss^{14,15}.

The radiation absorbed by the tissues produce a temperature rise which is dependent on the cooling mechanisms of the tissue. When the thermoregulatory capability of the system or parts of the system is exceeded, tissue damage and death can result. As the energy absorption steadily increases, the protective mechanisms for heat control breaks down, resulting in an uncontrolled rise in body temperature. These results have been demonstrated on dogs and rats^{16,17}.

Conclusion

From the above analysis, it is concluded that in human body exposed to high frequency radiation, SAR of the biological material is higher than the safe limit prescribed by WHO and ICNIRP. But, the EMWs of all the frequencies transmitted by the TV tower are not harmful on human body at every distance from the tower. EMWs of some specific frequencies are harmful within particular distances from the tower. For example, EMWs of frequencies 41 MHz and 202 MHz incident on the human body have no harmful effect on fat of human body (as SAR remains below the permissible limit at all distances from the tower), while SAR values for EMW of these frequencies exceed permissible limit for skeletal muscles within the range of 100 m distance from tower. The distance for SAR value exceeding

permissible limit varies for different parts and also with frequency. SAR value for 41 MHz is above the permissible limit for bone cortical and bone spongy within in the range of 1 m distance from the transmission tower and EMW of frequency 202 MHz for bone cortical and bone spongy is above that limit within the range of 10 m distance from the tower.

Thus, it is suggested that transmission towers should be located away from the thickly populated areas and people should keep away from the transmission towers, as they radiate electromagnetic radiations that are harmful for.

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