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# 3G, 4G, 5G CELL TOWER AND THEIR EFFECTS ON HUMAN HEALTH: CASE STUDY OF THE BRAIN

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**Abstract - Everyday activities of human life is full of exposure to electromagnetic radiation either from mobile cell towers, mobile phones, radio station transmitters as well as the electric transmission lines. Radio frequency electromagnetic radiation from mobile phones is classified as non-ionization radiation but the fact still remains that this radiation has effect on human health. Radio frequency (RF) electromagnetic radiation is use in mobile phone to transmit information between handsets and base stations either in analog or digital form. Mobile phone system uses different signals (different frequency bands and information coding methods) for their transmission. In recent time it has been said that there will be transition from 3G&4G to 5G in view of this, the study will show the effect of the radiation as related to Specific Absorption Rate of mobile phones as well as the frequency of operation and how this affects human health.**

Keywords- Electromagnetic, Radio-Frequency, Transmission, Coding, Non-Ionization, Radiation, Specific Absorption Rate

## I. INTRODUCTION

A vast increase in mobile cell phones subscriber has generate a lot of public concern especially the 5G network about the possible or related adverse effect in both human, animals and all living organism as a result of exposure to this radiation from mobile phone cell tower or cell phone itself.

Ayeni et al, 2011 described such radiation from cell tower and mobile phones as a non-ionization radiation. Shivers et al, 1987 examined the effect of magnetic resonance imaging upon the rat brain with more research showing that rabbit exposed to

radiation became blind after 100days of exposure. In 2019 a female rabbit was exposed to radiation from mobile phone by Dr Y.O. Olasoji and A.N Adefela with SAR value of 1.6W/kg operating at 900MHz for over 120days which eventually increases the temperature of the rabbit fallopian tube which destroys the babies produced by the rabbit. The voluntary exposure of the brain to radiation from mobile cell phones mostly by ¼ subscribers has been called the largest human biological experiment ever (Salford et al. 2011).

When using mobile phones, electromagnetic wave is transferred to the body which causes health problems especially at the place near ear skull region where they are known to affect neuron because all cell towers and mobile phones radiate or emits radio frequency radiation during signal propagation which makes it extremely dangerous to human, animals and plants. Transition plan made to move from both 3G and 4G to 5G across globe has generated more concern about the health effect which will be by this transition on human health. In less than few month every villages, town, cities, countries and the entire globe will operate mobile communication system using 5G technology and as a result of this every existing mobile phone tower will be linked up with the mini 5G cell tower in our neighborhood and cities both beside and on-top of our houses including the street light poles. Since the 5G is designed to operates on ultra high frequency, ultra high intensity, millimeter wave-length and high penetration power resulting into spontaneous disintegration of quantum energy at high rate and since the frequency is of high the wave length is small which makes it travel less and as a result of this many and more mini cell towers will be installed at few meters to each other making all environment be more dense populated with electromagnetic radiation.



**II. LITERATURE REVIEW**

Various controlled scientific studies on 2G, 3G and 4G technologies show that stress, brain damage, sperm and testicular damage, neuropsychiatric effects, fatigue, dizziness, oedema, change in electrical impulse in human brain, cellular DNA damage can all occur in humans as a result of exposure to electromagnetic from mobile phone. Seybold, 2005 study human biological tissue as a lossy dielectric materials with permeability equal to free space permeability ( $\mu=\mu_0$ ) and conductivity that depends on tissue properties and signal frequency. Pelvig et al, 2008 sees human brain as the most complex organ in a vertebrate body in a typical human, the cerebral cortex is estimated to contain 15-33 billion neuron each connected by synapses.

Sarah Drieben of the research center for electromagnetic environment compatibility at Germany’s university of Aachen show a strong connection between radiofrequency field of an existing standards and cancer in rats. In a test carried out in a mice exposed to EMFs for nine (9) hours a day for a period of 2years brings about drastic changes in the nervous system of the mice including the brain, heart and testes all conducted using 3G network. Epidemiological evidence was subsequently reviewed and incorporate in a metal-analysis by Rooli et al concluded that overall epidemiological evidence does not suggest increased brain or salivary gland tumor risk with mobile phone use although the authors admitted that some uncertainty remains regarding long latency periods (>15 years) rare brain tumor sub types with mobile usage during childhood.

**III. METHODOLOGY**

The method used in this research work is based on the comparison between Specific Absorption Rate and the average frequency of operation of mobile carrier. This is done by adopting some formula such as Maxwell equation  $SAR=\frac{\partial(E^2)}{2\rho}$ .....1 . Where E is the electric field intensity, where  $\rho$  is the tissue density and  $\partial$  is the tissue conductivity where power density is given  $\rho$  as  $\frac{\partial(E^2)}{2}$ .....2. Since most mobile phones are placed close to the head we consider the brain tissues and also some tissues in the body using radiofrequency penetrating dept formula as  $\delta = \frac{1}{\sqrt{\pi\mu\partial f}}$  .....3,where  $\delta$  the depth of penetration,  $\mu$  is the permeability of human tissue which is equal to permeability of free space =  $4\pi\times 10^{-7} Hm^{-1}$  .

Power density of the GSM mobile phone is given as  $P_d = \frac{ERP}{4\pi(d+\delta)^2} = \frac{P_t G_t}{4\pi(d+\delta)^2}$  .....4 where  $P_t$  is the average power transmitted by phone,  $G_t$  is the unity (1) gain of the antenna since the antenna is always transmitting the signal in a single direction towards the head while  $d$  is the distance of the antenna to the head depending on the user but assumption in this research work is based on the average of the distance between 0.5cm-2cm with an average of 1.25cm.  $P_t$  is giving as one eight of the average power radiated by the GSM which is  $0.125\times 1.6W/kg = 0.2W$ . The induced electric field and magnetic field exert pressure on the tissue around it and interact with the materials. Since the velocity of propagation in human tissue is lower than that of free space we have it to be  $3\times 10^8m/s$  while the impedance of human tissue is giving as  $\eta=\eta_0\sqrt{\frac{\mu r}{\epsilon r}}$ .....5

Where  $\eta_0=377ohms$ . Relating power density  $P_d$ , the impedance of the medium ( $\eta$ ), the electric field (E) and the magnetic field (H) we have  $P_d = (E^2/\eta) = H^2\eta$ .....6.

Since the body is a weak magnetic material therefore  $\mu_r = 1$  and the relative permeability of the brain is 1.

Table 1: below show the permittivity, conductivity and dielectric properties of human tissue with different frequency range.

Layer	Relative permittivity			Conductivity (S/m)		
	900 MHz	1800 MHz	2.4 GHz	900 MHz	1800 MHz	2.4 GHz
Skin	41.4	38.9	38.1	0.87	1.18	1.44
Fat	5.46	5.34	5.29	0.051	0.078	0.102
Bone	12.45	11.8	11.41	0.14	0.28	0.385
Dura	44.4	42.9	42.1	0.96	1.32	1.64
CSF	68.7	67.2	66.3	2.41	2.92	3.41
Brain	45.8	43.5	42.6	0.77	1.15	1.48

Source: <https://www.researchgate>.

Table 2 below show the electrical properties of human brain tissue from 5GHz-100GHz



Frequency GHz	Dry skin			Wet skin		
	$\sigma$ (S/m)	$\epsilon_r$	$d$ (mm)	$\sigma$ (S/m)	$\epsilon_r$	$d$ (mm)
5	3.06	35.77	10.49	3.57	39.61	9.49
10	8.01	31.29	3.80	8.95	33.53	3.53
14.5	13.27	26.88	2.16	14.08	28.62	2.10
20	19.22	21.96	1.38	19.71	23.77	1.39
30	27.10	15.51	0.85	27.52	17.74	0.88
31	27.69	15.030	0.82	28.151	17.294	0.85
40	31.80	11.69	0.65	32.87	14.09	0.67
45	33.94	10.40	0.59	34.94	12.81	0.605
50	34.62	9.40	0.54	36.69	11.77	0.56
60	36.40	7.98	0.48	39.52	10.22	0.49
70	37.58	7.04	0.43	41.71	9.12	0.43
80	38.40	6.40	0.40	43.46	8.32	0.40
90	38.99	5.94	0.38	44.90	7.72	0.37
100	39.43	5.60	0.36	46.12	7.25	0.35

Source : <https://www.researchgate>.

#### IV. RESULTS AND DISCUSSION

Table above shows the tissue properties of human with 3G and 4G networks with frequency of 900MHz and 1800MHz and the future 5G networks with a frequency range of 60GHz-100GHz. Since the mobile phone is held close to the head our focus is mainly the brain. Recall every mobile communication has both uplink and downlink so for GSM-900MHz, the medium link is 942.5MHz and for 1800MHz the medium link is 1842.5MHz. Calculating the depth of penetration we use equation...3

$$\delta = \frac{1}{\sqrt{\pi\mu\sigma f}}$$

##### A) Dept of penetration

At 900MHz the depth of penetration is  $\delta = \frac{1}{\sqrt{3.142 \times 4 \times 3.142 \times 10^{-7} \times 0.77 \times 942.5 \times 10^6}}$   
 = 0.01868m

At 1800MHz the depth of penetration is

$$\delta = \frac{1}{\sqrt{3.142 \times 4 \times 3.142 \times 10^{-7} \times 1.15 \times 1842.5 \times 10^6}}$$

= 0.01093m

At 60GHz the depth of penetration is

$$\delta = \frac{1}{\sqrt{3.142 \times 4 \times 3.142 \times 10^{-7} \times 36.4 \times 62.5 \times 10^9}}$$

= 0.000334m

Calculating the power density of the signal at 900MHz, 1800MHz and 60GHz using equation 4 above=  $\frac{P_t G_t}{4\pi(d+\delta)}$  assuming the specific absorption rate of the mobile phone is 1.6W/kg to 10gram of tissue and since only 0.125 of the power absorb by the body therefore we have  $P_t = 0.125 \times 1.6W/kg = 0.2W/kg$  where  $G_t$ = Antenna gain is 1 therefore the power density at 900MHz will be=  $\frac{0.2 \times 1}{4 \times 3.142(0.0125 + 0.01868)} = 16.37W/m^2$

At 1800MHz power density will be

$$\frac{0.2 \times 1}{4 \times 3.142(0.0125 + 0.01093)} = 28.99W/m^2$$

At 60GHz power density will be

$$\frac{0.2 \times 1}{4 \times 3.142(0.0125 + 0.000334)} = 96.61W/m^2$$

The electric field induced in the brain is calculated by calculating the impedance at each frequency level using equation 5

##### B) Impedance

$$\eta = \eta_0 \sqrt{\frac{\mu r}{\epsilon r}}$$

For 900MHz the impedance is

$$377\sqrt{1 \div 45.8} = 55.71 \text{ ohms}$$

At 1800MHZ the impedance is

$$377\sqrt{1 \div 43.5} = 57.16 \text{ ohms}$$

At 60GHz the impedance is

$$377\sqrt{1 \div 7.98} = 133.46 \text{ ohms}$$

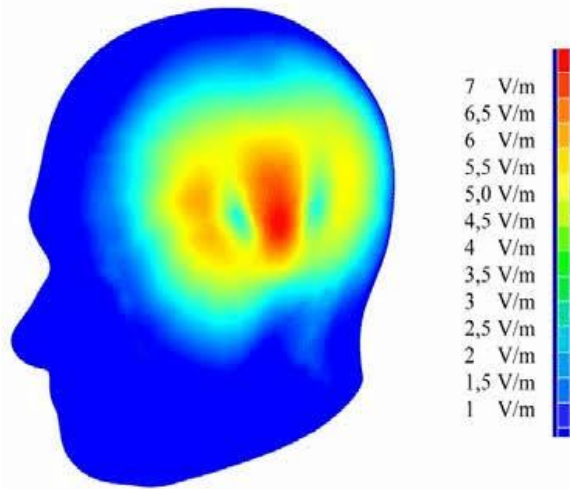
##### C) Induce electric field

The induced electric field is calculated using the equation  $E = \sqrt{(P_d \times \eta)}$

At 900MHz  $E = \sqrt{16.37 \times 55.71} = 30.198V/m$

At 1800MHz  $E = \sqrt{28.99 \times 57.16} = 40.71V/m$

At 60GHz  $E = \sqrt{96.61 \times 133.46} = 113.55V/m$



Source: <http> the image above shows mobile phone power at 0.8W with a specific absorption rate of 0.6W/kg with maximum induced electric field at 7V/m at 900MHz as compared to our calculated value.

#### V. OBSERVATION

From the above result it is observed that an increase in frequency with a mobile phone of high SAR value increases the power density of the signal as well as the impedance of the signal which in-turn increases the induce electric field near the tissue. Since power density increases with increase in frequency more heat are generated which in-turn heated up the cells around the region and damaged the cells and tissues around there. Also the induced electric field increases with increase in frequency thereby raising the temperature of the surrounding which in-turn increases the temperature around the cells and tissues.

#### VI. RECOMMENDATION

From the above study it is recommended that the frequency of operation of the fifth generation (5G) should be reduced to minimal frequency so as to reduce the power density as well as to reduce the induced electric field. The specific absorption rate of mobile phone sold in the market must be reduced to values to 0.6W/kg which will make subscribers to be as save as possible. More so mobile phone subscriber should be advice to make use of quantum shield, wired headset when making calls and also subscriber should use text messages in replacement of long calls.

#### VII. CONCLUSION

From the studies we saw that the GSM we are using can have effect on surrounding of our brain but not something that we can see. Over long period of time the effect of the radiation begins to show up as human is ageing. In conclusion we suggest a drastic reduction in the frequency of operation of the 5<sup>th</sup> generation mobile network or be suspended until further review.

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