

REPORT
ON
CELL TOWER RADIATION

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Secretary, DOT, Delhi



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CELL TOWER RADIATION REPORT

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1. Advantages and disadvantages of cell phone technology

Cell phone technology has revolutionized the telecommunication scenario in India. Due to its several advantages, cell phone technology has grown exponentially in the last decade. Currently, there are more than 50 crore cell phone users and nearly 4.4 lakh cell phone towers to meet the communication demand. The numbers of cell phones and cell towers are increasing without giving due respect to its disadvantages. All over the world, people have been debating about associated health risk due to radiation from cell phone and cell tower. Radiation effects are divided into thermal and non-thermal effects. Thermal effects are similar to that of cooking in the microwave oven. Non-thermal effects are not well defined but it has been reported that non-thermal effects are 3 to 4 times more harmful than thermal effects.

A cell phone transmits 1 to 2 Watt of power in the frequency range of 824 - 849 MHz (CDMA), 890 - 915 MHz (GSM900) and 1710 – 1780 MHz (GSM1800). A cell phone has a SAR (Specific Absorption Rate) rating. In USA, SAR limit for cell phones is 1.6W/Kg which is actually for 6 minutes per day usage. It has a safety margin of 3 to 4, so a person should not use cell phone for more than 18 to 24 minutes per day. This information is not commonly known to the people in India, so crores of people use cell phones for more than an hour per day without realizing its associated health hazards.

Cell tower antennas transmit in the frequency range of 869 - 894 MHz (CDMA), 935 - 960 MHz (GSM900) and 1810 – 1880 MHz (GSM1800). Also, 3G has been deployed in a few cities, in which base station antenna transmits in the frequency range of 2110 – 2170 MHz. Mobile phone operators divide a region in large number of cells, and each cell is divided into number of sectors. The base stations are normally configured to transmit different signals into each of these sectors. In general, there may be three sectors with equal angular coverage of 120 degrees in the horizontal direction as this is a convenient way to divide a hexagonal cell. If number of users is distributed unevenly in the surrounding area, then the sectors may be uneven. These base stations are normally connected to directional antennas that are mounted on the roofs of buildings or on free-standing masts. The antennas may have electrical or mechanical down-tilt, so that the signals are directed towards ground level.

A base station and its transmitting power are designed in such a way that mobile phone should be able to transmit and receive enough signal for proper communication up to a few kilometers. Majority of these towers are mounted near the residential and office buildings to provide good mobile phone coverage to the users. These cell towers transmit radiation 24x7, so people living within 10's of meters from the tower will receive 10,000 to 10,000,000 times stronger signal than required for mobile communication. In India, crores of people reside within these high radiation zones.

2. Radiation from the cell tower

A GSM900 base station antenna transmits in the frequency range of 935 - 960 MHz. This frequency band of 25 MHz is divided into twenty sub-bands of 1.2 MHz, which are allocated to various operators. There may be several carrier frequencies (1 to 5) allotted to one operator with upper limit of 6.2 MHz bandwidth. Each carrier frequency may transmit 10 to 20W of power. So,

one operator may transmit 50 to 100W of power and there may be 3-4 operators on the same roof top or tower, thereby total transmitted power may be 200 to 400W. In addition, directional antennas are used, which typically may have a gain of around 17 dB (numeric value is 50), so effectively, several KW of power may be transmitted in the main beam direction.

2.1 Radiated power density from the cell tower

Power density P_d at a distance R is given by

$$P_d = \left(\frac{P_t \times G_t}{4\pi R^2} \right) \text{ Watt/m}^2$$

where, P_t = Transmitter power in Watts

G_t = Gain of transmitting antenna

R = Distance from the antenna in meters

For $P_t = 20 \text{ W}$, $G_t = 17 \text{ dB} = 50$, P_d for various values of R is given in Table 1.

Table 1 – Power density at various distances from the transmitting tower

Distance R (m)	Power density P_d in W/m^2	Power density P_d in $\mu\text{W/m}^2$
1	79.6	79,600,000
3	8.84	8,840,000
5	3.18	3,180,000
10	0.796	796,000
50	0.0318	31,800
100	0.008	7,960
500	0.000318	318

The power density values given in Table 1 are for a single carrier and a single operator. If multiple carriers are being used and multiple operators are present on the same roof top or tower, then the above values will increase manifold. However, radiation density will be much lower in the direction away from the main beam. One should know actual radiation pattern of the antenna (which unfortunately is not made public) to calculate exact radiation density at a point.

2.2 Radiation pattern of the antenna

The simulated radiation pattern of GSM900 antenna of approximately 17 dB gain at 950 MHz of size 2400 mm x 30 mm is shown in Fig. 1. Radiation pattern of the antenna is shown in two planes – horizontal and vertical. There is one main lobe and several side lobes. For the main lobe, half-power beam-width (HPBW – defined as angular range over which maximum power decreases to half of its value) in the horizontal direction is 65 degrees and HPBW in the vertical direction is 6 degrees. There are several side lobes, whose maximum levels are about -13 to -20 dB below the main level.

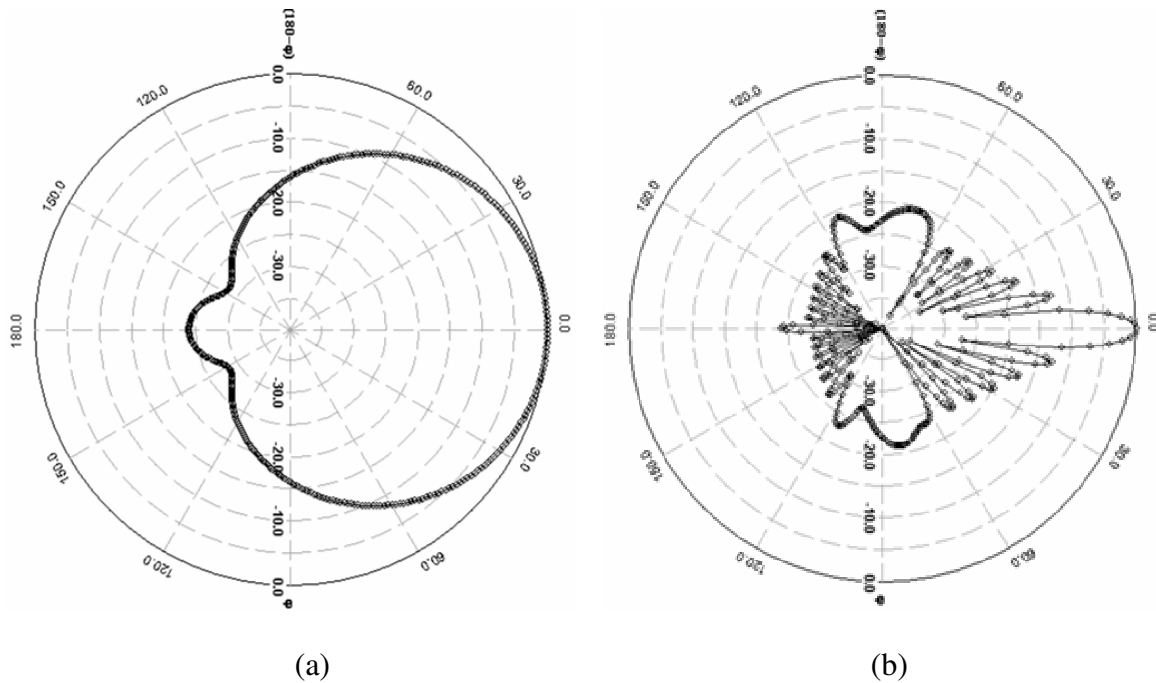


Fig. 1 – (a) Horizontal and (b) Vertical radiation pattern of a 17 dB gain antenna

2.3 Case study of Usha Kiran Building, Mumbai

Through the help of the above typical radiation pattern, let's analyze the news reported in Mid-day, Mumbai dated Jan. 3, 2010, which stated - "Mumbai's swanky Usha Kiran building says the four cancer cases there could be linked to mobile towers installed on the facing Vijay Apartments". The picture taken from the Usha Kiran building of the several antennas installed on the seventh floor of Vijay Apartments is shown in Fig. 2. People living in the 6th, 7th and 8th floor in the opposite building will get maximum radiation as they are in the main beam direction. People living on the other floors will receive lesser radiation as beam maxima is reduced considerably as can be observed from vertical radiation pattern. In the horizontal direction again, people living in the front side of the antenna will receive much higher radiation compared to people living in the back side of antenna.

<http://www.mid-day.com/news/2010/jan/030110-mobile-tower-cancer-cases-carmichael-road-posh-areas.htm>



Fig. 2 – Cell phone towers installed at the roof top of a building in Mumbai

From Table 1, it may be noted that for a single transmitter, power density at $R = 50\text{m}$ is equal to $0.0318\text{W/m}^2 = 31,800 \mu\text{W/m}^2$. Even for 3 transmitters in the same direction, it comes out to be approximately $0.1 \text{ W/m}^2 = 100,000 \mu\text{W/m}^2$, which has caused cancer to several people in a duration of 2 to 3 years.

3. Radiation norms adopted in different countries

In India, we have adopted radiation norms given by ICNIRP guidelines of 1998 for safe power density of $f/200$, where frequency (f) is in MHz. Hence, for GSM900 transmitting band (935-960 MHz), power density is 4.7W/m^2 and for GSM1800 transmitting band (1810-1880 MHz), it is 9.2W/m^2 . The ICNIRP guidelines clearly state that for simultaneous exposure to multiple frequency fields, the sum of all the radiation must be taken into consideration. However, in India, we have applied this limit to individual carrier, so the radiation level exceeds by several times than even prescribed by ICNIRP guidelines, depending upon the total number of transmitters in that area. Some of the people (especially older people, house wives, small children) living near the towers are exposed to this radiation 24 hours a day. Unfortunately, ICNIRP has considered only the thermal effects of radiation, whereas scientists all over the world have found non-thermal effects of these radiations to have significant health effects and these non-thermal health effects occur at levels much below these norms.

Bio-Initiative Report in 2007 (610 pages long) has been prepared by a group of independent scientists after thorough and very careful survey of the literature and they concluded that the existing standards for public safety are inadequate to protect public health and proposed $1000 \mu\text{W/m}^2$ for outdoor, cumulative RF exposure. Some of the proposed maximum exposure values through various reports are given below:

•Building Biology Institute, Germany, provided following guidelines for exposure:

- $<0.1 \mu\text{W}/\text{m}^2$ ($0.00001 \mu\text{W}/\text{cm}^2$) - no concern
- $0.1 - 10 \mu\text{W}/\text{m}^2$ (0.00001 to $0.001 \mu\text{W}/\text{cm}^2$) - slight concern
- $10 - 1000 \mu\text{W}/\text{m}^2$ (0.001 to $0.1 \mu\text{W}/\text{cm}^2$) - severe concern
- $> 1000 \mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$) - extreme concern

•H Thomas et al, Germany; power densities should not exceed $100 \mu\text{W}/\text{m}^2$

•EU Parliament (STOA 2001) recommends - $100 \mu\text{W}/\text{m}^2$

The current USA standard for radiation exposure from cell phone towers is 580-1,000 microwatts per sq. cm. ($\mu\text{W}/\text{cm}^2$), but they are now considering revising the norms. Over 100 physicians and scientists at Harvard and Boston University Schools of Public Health have called cellular towers a radiation hazard. And, 33 delegate physicians from 7 countries have declared cell phone towers a “public health emergency”. Many countries in the world have adopted much stricter maximum radiation density values of 0.001 to $0.24 \text{ W}/\text{m}^2$ ($1/100^{\text{th}}$ to $1/1000^{\text{th}}$ of ICNIRP guidelines) as shown in Table 2. The people in these countries have studied extensively the health hazards of cell tower radiation to adopt stricter radiation norms. As can be seen in the case described in Section 2.3, even $0.1 \text{ W}/\text{m}^2 = 100,000 \mu\text{W}/\text{m}^2$ has caused cancer to several people in a duration of 2 to 3 years.

Table 2 - International Radiation Density Limits for GSM1800

Power Density (W/m^2)	International Exposure limits adopted by various countries
10	FCC (USA) OET-65, Public Exposure Guidelines at 1800 MHz
9.2	ICNIRP and EU recommendation 1998 – Adopted in India
3	Canada (Safety Code 6, 1997)
2	Australia
1.2	Belgium (ex Wallonia)
0.5	New Zealand
0.24	Exposure limit in CSSR, Belgium, Luxembourg
0.1	Exposure limit in Poland, China, Italy , Paris
0.095	Exposure limit in Italy in areas with duration > 4 hours
0.095	Exposure limit in Switzerland
0.09	ECOLOG 1998 (Germany) <i>Precaution recommendation only</i>
0.025	Exposure limit in Italy in sensitive areas
0.02	Exposure limit in Russia (since 1970), Bulgaria, Hungary
0.001	"Precautionary limit" in Austria, Salzburg City only
0.0009	<i>BUND 1997 (Germany) Precaution recommendation only</i>
0.00001	New South Wales, Australia

At many places, cell phone towers are mounted on the roof top of residential /commercial buildings. Even though antenna radiates less power vertically down but the distance between the antenna and top floor is usually a few meters, so the radiation level in the top two floors remain very high. From Table 1, power density at $R = 3\text{m}$ is equal to $8,840,000 \mu\text{W}/\text{m}^2$ in the main beam. In the vertically down direction, radiation is approximately 20-22 dB less and the roof may provide attenuation of 6 to 10 dB depending on the construction (implying $1/1000^{\text{th}}$ power), implying radiation density of $8,840 \mu\text{W}/\text{m}^2$, which is still very high.

Let's do some simple calculation of how much microwave power will be absorbed by human body if exposed to the so called safe radiation level adopted in India of power density = $4.7 \text{ W}/\text{m}^2$ for GSM900 band,. If we model human body as a cylinder, then its area will be 1.436 square meter (average height $5'6'' = 1.67 \text{ m}$ and waist $34'' = 86 \text{ cm}$). So, power recd. by human body will be power density $\times$ area = 6.75 Watts. In one hour, microwave energy absorbed will be $6.75 \times 3600 = 24.3 \text{ KW-sec}$. In one day, microwave energy absorbed will be $24.3 \times 24 = 583.2 \text{ KW-sec}$. A typical microwave oven has a rating of 700 to 1000 W , and with say 60% efficiency, microwave power output is approximately 500 W . This implies that human body can be safely kept in a microwave oven for $583.2 \text{ KW-sec} / 500 \text{ W} = 1166 \text{ seconds} = 19 \text{ minutes}$ per day. How many people in the world are willing to put themselves, their family members, and their unborn children in an open microwave oven for 19 minutes/day ? Telecom providers or policy makers can argue about body being adaptable to external threats and the radiation is spread over whole day. However, question remains, would we like to put our citizens in an open microwave oven for 19 minutes/day over the years. Also, this is only for a single source. For multiple sources, it will increase correspondingly. Thus, the safe limit adopted by India is extremely high and millions of people are suffering because of this.

Interphone study in 2010 mentions that excessive use of mobile phones has doubled to quadrupled brain tumor risk. However, they claim that for an average user, increase in cancer cases is not significant but they have taken an average user as a person who uses cell phone for 2 hours/month . In India, many people use cell phones for 1 to 2 hours per day . Re-evaluation of the Interphone study by a group of eminent scientist has found that the risk of affected people is significantly higher than reported. Interphone Study excluded children from the study. Children are at higher risk from exposures to carcinogens than adults and today very large population of children are using cell phones and also many of them sleep with the cell phones beneath their pillows every night without realizing the health hazards.

A number of adverse health effects have been documented at levels below the FCC guidelines, which include altered white blood cells in children; childhood leukemia; impaired motor function, reaction time, and memory; headaches, dizziness, fatigue, weakness, and insomnia etc. Figure 3 shows guidelines adopted by various countries in the top right corner and health effects of radio frequency radiation at various power densities at much lower level.

Guidelines for various countries

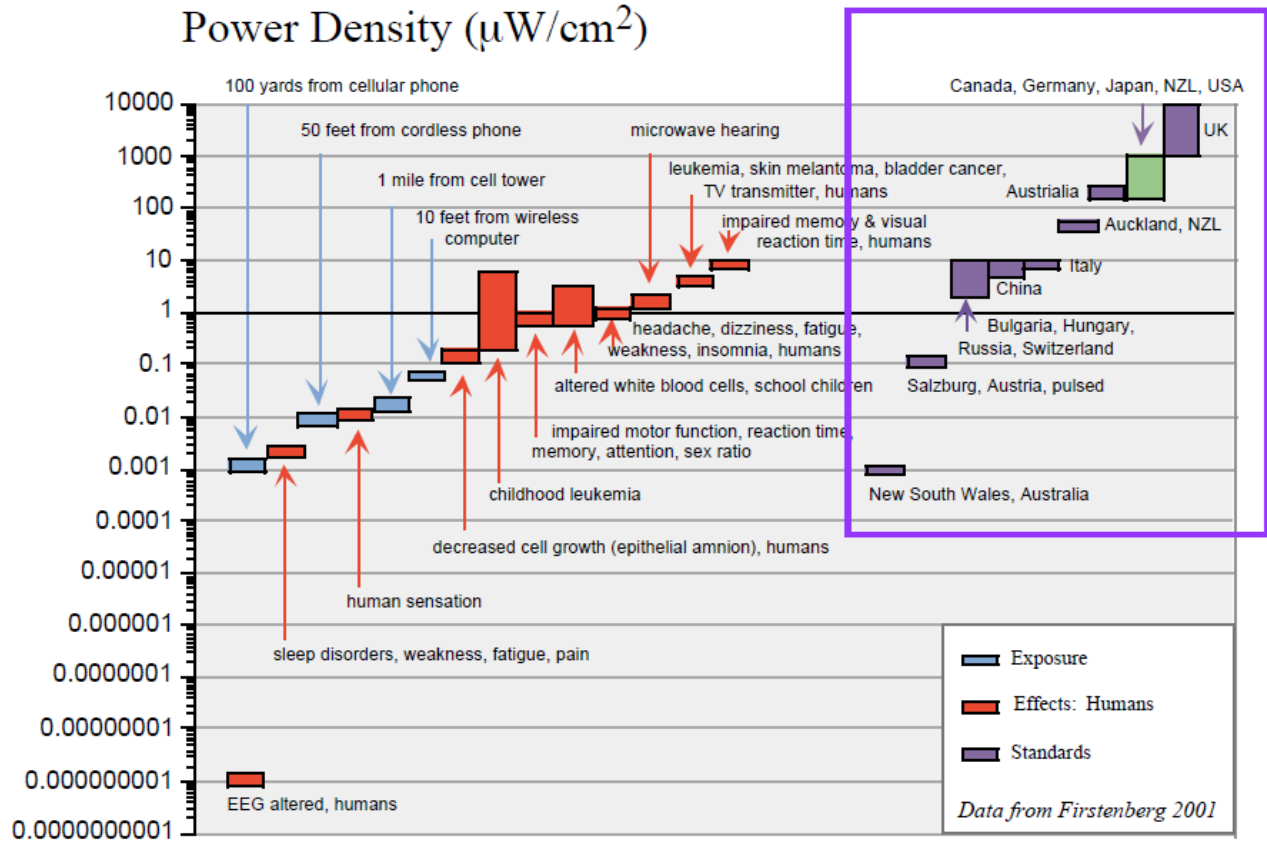


Figure 3: Guidelines, exposures and effects of radio frequency radiation at various power densities. Data from Firstenberg 2001.

4. Theoretical and Measured Radiated power

To measure the power at a distance R , an antenna is used to receive the power and a spectrum analyzer or power meter is used to measure received power.

Power Received P_r by an antenna at a distance R is given by:

$$P_r = P_t \times G_t \times G_r \times \left(\frac{\lambda}{4\pi R} \right)^2$$

Received power is directly proportional to the transmitted power, gain of transmitting and receiving antennas, and square of wavelength of the signal and it is inversely proportional to square of distance. For transmitter power $P_t = 20 \text{ W}$, transmitting antenna gain $G_t = 17 \text{ dB}$, receiving monopole antenna gain $G_r = 2 \text{ dB}$, the received power at $R = 50 \text{ m}$ is:

At 887 MHz (tower transmitting frequency in CDMA), $P_r = -3.2 \text{ dBm}$.

At 945 MHz (tower transmitting frequency in GSM900), $P_r = -3.8$ dBm.

At 1872 MHz (tower transmitting frequency in GSM1800), $P_r = -9.7$ dBm

The purpose of a cell tower is that mobile phone should receive adequate signal for its proper operation. A mobile phone shows full strength at -69 dBm input power and works satisfactorily in the received power range of -80 to -100 dBm. In comparison with -80 dBm level, the measured power level at $R = 50$ m is at least 50 to 60 dB higher, which translates to 100,000 to 1,000,000 times stronger signal than a mobile phone requires. There are millions of people who live within 50m distance from cell towers and absorbing this radiation 24x7.

4.1 Conversion from measured power to power density

These measured power levels are in dBm whereas international standards are in terms of power density. In Table 3, conversion from measured power in dBm using a monopole antenna of gain = 2 dB (radiation monitor consists of this antenna) to power density is given.

Table 3 - Conversion from Power received from a monopole antenna of gain = 2 dB to Power Density at different frequencies.

Power received	Power density for different frequencies (Micro Watt/sq. meter)		
	f = 900 MHz	f = 1800 MHz	f = 2450 MHz
10 dBm = 10 mW	706,860	2,827,440	5,238,180
3 dBm = 2.0 mW	141,372	565,488	1,047,636
0 dBm = 1.0 mW	70,686	282,744	523,818
-7 dBm = 200 μ W	14,137	56,549	104,764
-10 dBm = 100 μ W	7,068.6	28,274.4	52,382
-17 dBm = 20 μ W	1,414	5,655	10,476
-20 dBm = 10 μ W	706.9	2,827.4	5,238
-27 dBm = 2 μ W	141.4	565.5	1,048
-30 dBm = 1 μ W	70.7	282.7	523.8
-37 dBm = 0.2 μ W	14.1	56.6	104.8
-40 dBm = 0.1 μ W	7.1	28.3	52.4

where

f = 900 MHz is approximately the center frequency of CDMA tower (869 to 890 MHz) and GSM900 tower (935 to 960 MHz) transmit frequency bands

f = 1800 MHz corresponds to GSM1800 cell tower (1810 to 1880 MHz) transmit frequency band.

f = 2450 MHz is approximately the center frequency of WiFi, WLAN, Bluetooth, Microwave oven, etc.

4.2 Measurement at a cancer's patient residence

Since the radiation effect on the human body is cumulative, a hand held broadband radiation monitor (Frequency range of 800 to 2500 MHz) has been developed to measure the total received power. Radiation measurements were carried out in a lady's apartment, who had developed cancer within one year of installation of cell tower. The layout of the apartment and the measured readings are shown in Fig. 3. It may be noted that the radiation level is very high and it is between – 4 to -10 dBm. At 900 MHz, -10 dBm received power is equivalent to $7,068 \mu\text{W}/\text{m}^2$, again implying that safe radiation norms must be reduced considerably than adopted by India, which is $4.7\text{W}/\text{m}^2 = 4,700,000 \mu\text{W}/\text{m}^2$.

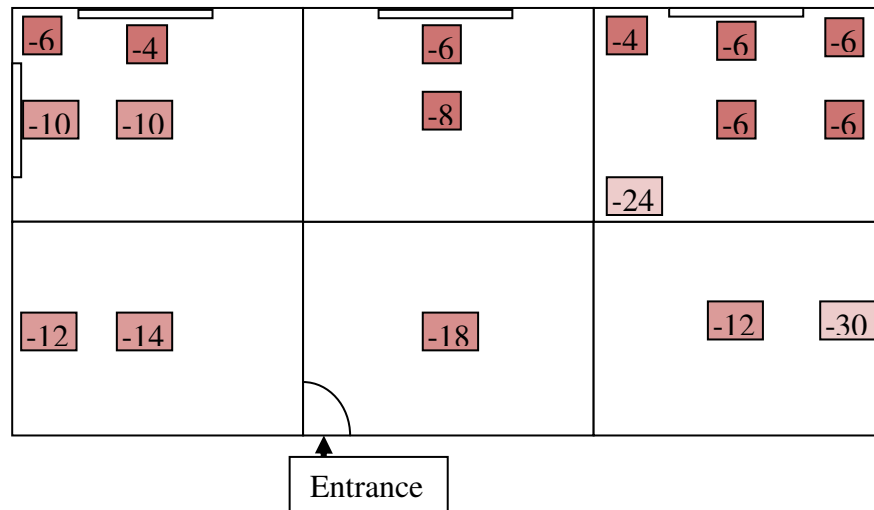


Fig. 3 – Measured power at a cancer patient's residence

4.3 Radiation Measurement at various places

Radiation measurements were carried out at various places in Gurgaon, Delhi and Mumbai. Some of these readings are given in Table 4. It may be noted that on Delhi-Gurgaon Highway bridge after Toll Naka towards Delhi, the measured radiated power was as high as 0 dBm, which is equivalent to $70,686 \mu\text{W}/\text{m}^2$ as there are 3 cell towers near the highway.

Table 4 – Measured Radiated power and power density at various locations

Location	Measured power in dBm	Power Density in W/m²	Power Density in μW/m²
Delhi-Gurgaon Highway near Toll (3 towers)	0	0.70686	70,686
Khar Bridge, Mumbai	0	0.70686	70,686
Bridge b/w Vashi and Sanpada, Navi Mumbai	-4	0.028274	28,274
Worli Naka	-4	0.028274	28,274
Tilak Bridge, Dadar	-4	0.028274	28,274
Resident 1, 4 th Fl. Sergeant House Lady w/cancer	-6	0.017756	17,756
Bandra Bridge	-6	0.017756	17,756
Airport Bridge	-6	0.017756	17,756
Resident 2, Rane Society, Powai	-10	0.007069	7,069
Near Hub mall, Goregaon	-10	0.007069	7,069
Mahalaxmi Temple, Bhulabhai Desai Road	-10	0.007069	7,069
Haji Ali, Juice Centre	-10	0.007069	7,069
IIT Bombay, Main Building	-10	0.007069	7,069
Gandhi Nagar-over railway bridge-near building	-12	0.00446	4,460
JK Cement group, Worli	-12	0.00446	4,460
Ustav Chowk, Kharghar	-12	0.00446	4,460
Siddhivinayak Temple	-14	0.002814	2,814
Vikroli - before Godrej	-14	0.002814	2,814
Govandi- Residential towers - near Indian Oil	-14	0.002814	2,814
Kemp's Corner	-14	0.002814	2,814
Race Course- Haji Ali	-14	0.002814	2,814
Powai Plaza	-14	0.002814	2,814
Belapur Flyover, near RBI- CIDCO	-16	0.001776	1,776
Vile Parle	-16	0.001776	1,776
Peddar Road (Punjab National Bank)	-16	0.001776	1,776
Dadar Plaza	-16	0.001776	1,776
Poddar Medical College	-16	0.001776	1,776
Vashi Highway – near Turbhe	-18	0.00112	1,120
Andheri Bridge- continuous high till Jogeshwari	-18	0.00112	1,120
Nerul Bridge	-20	0.00707	707
Vivero pre School (opposite powai lake)	-22	0.000446	446
Powai police station	-22	0.000446	446
L&T Bridge	-24	0.000446	281.4
Rajeev Gandhi nagar	-26	0.000177	177
On road near Evita (Hiranandani Building)	-28	0.000112	112
D-Mart, Hiranandani, Powai	-34	0.000028	28
Poddar Road opp. Mukesh Ambani Residence	-36	0.000028	17.8
IIT Bombay School of Management - Entrance	-46	0.00000178	1.78
Resident at Central Area, IIT Bombay	-56	0.000000178	0.178

5. Biological effects of microwave radiation

When a human body is exposed to the electromagnetic radiation, it absorbs radiation, because human body consists of 70% liquid. It is similar to that of cooking in the microwave oven where the water in the food content is heated first. Microwave absorption effect is much more significant by the body parts which contain more fluid (water, blood, etc.), like the brain which consists of about 90% water. Effect is more pronounced where the movement of the fluid is less, for example, eyes, brain, joints, heart, abdomen, etc. Also, human height is much greater than the wavelength of the cell tower transmitting frequencies, so there will be multiple resonances in the body, which creates localized heating inside the body. This results in boils, drying up of the fluids around eyes, brain, joints, heart, abdomen, etc.

There are several health hazards associated with cell phones and cell towers. Some of these are described in the following sub-sections.

5.1 The Blood Brain Barrier

The brain is protected by tight junctions between adjacent cells of capillary walls by the blood-brain barrier (BBB), which selectively lets nutrients pass through from the blood to the brain, but keeps toxic substances out. Experiments conducted on young laboratory rats found that RF from mobile phones can significantly open the BBB in animals and cause leakage of albumin from blood vessels in inappropriate locations (neurons and glial cells surrounding the capillaries) in the brain. This is shown in Fig. 4 as dark dots in the exposed brain on the right side. Control animals, in contrast, showed either no albumin leakage or occasional isolated spots, as seen on the left side. The presence of albumin in brain tissue is a sign that blood vessels have been damaged and that the brain has lost some of its protection.



Figure 4 - Comparison of brains from unexposed and exposed rats

A closer look at the cells within the brain also revealed that exposed animals had scattered and grouped dark neurons often shrunken with loss of internal cell structures. Neuronal damage of this kind may not have immediate consequences but in the long run, it may result in reduced brain reserve capacity that might be unveiled by other later neuronal diseases. It must be noted that the blood-brain barrier and neurons are the same in a rat and a human being.

In another research, a single two-hour exposure to a cell phone just once during its lifetime, permanently damaged the blood-brain barrier and, on autopsy 50 days later, was found to have damaged or destroyed up to 2 percent of an animal's brain cells, including cells in areas of the brain concerned with learning, memory and movement. It is known that this barrier is damaged in Alzheimers and Parkinsons disease. So there is a risk that disruption of this protection barrier may damage the brain.

5.2 Risk to Children and Pregnant Women

Children are more vulnerable to cell phone radiation as they:

- Absorb more energy than adults from the same phone owing to their smaller head and brain size, thinner cranial bones and skin, thinner, more elastic ears, lower blood cell volume, as well as greater conductivity of nerve cells and the energy penetrates more deeply. Tumors in the mid brain are more deadly than in the temporal lobe,
- Children's cells reproduce more quickly than adults which makes cancers more deadly,
- Their immune system is not as well developed as adults hence are less effective against fighting cancer growth,
- Children have longer life time exposure.

Absorption of electromagnetic radiation from a cell phone (Frequency - GSM 900 MHz) is shown in Fig. 5 by an adult, 10 year old and a 5 year old child. When radiation hits the head, it penetrates the skull. The yellow area at the bottom is the location of the cell phone by the ear. The radiation penetrates the skull of an adult (25%), 10 year old (50%) and a 5 year old (75%).

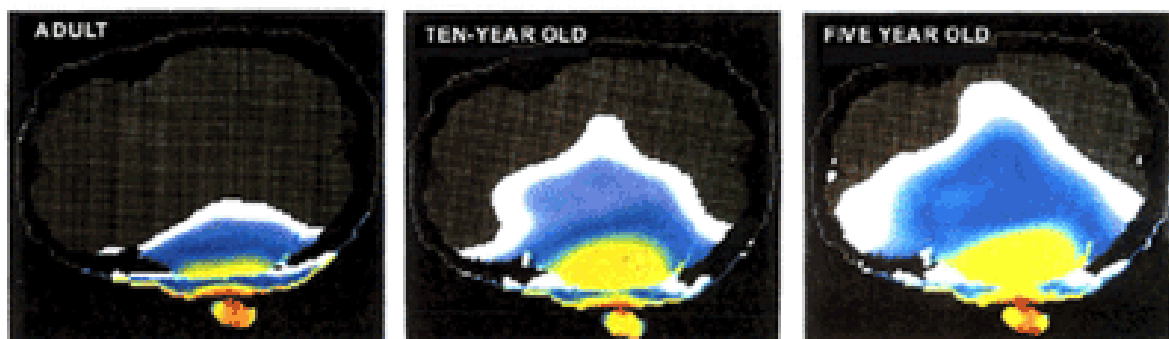


Fig. 5 - Absorption of electromagnetic radiation from a cell phone based on age (Frequency GSM 900 MHz)

The younger the child, the deeper is the penetration due to the fact that their skulls are thinner and still developing. For these reasons it is critical that children under the age of 16 use cell phones only for short essential calls as they have much bigger danger of getting a brain tumor. Brain tumors have now taken over leukemia as the biggest cause of death amongst children. Due to these reasons countries like Belgium, France, Finland, Germany, Russia and Israel have publicly discouraged use of cell phones by children. An Independent research in Sweden last year concluded there was an astonishing 420 percent increased chance of getting brain cancer for cell phone users who were teenagers or younger when they first started using their phones.

A pregnant woman and the fetus both are vulnerable because of the fact that these RF radiations continuously react with the developing embryo and increasing cells. Microwave radiation can damage the placental barrier; the membrane which prevents the passage of some materials between the maternal and fetal blood, protecting the fetus, implying that pregnant woman should avoid cell phone or use during emergency.

In a recent finding, an association was found between a mother's cell phone use during pregnancy and greater likelihood for spontaneous abortion, congenital malformations and behavioral problems in their children. It is believed that the eggs, which form the embryo, are affected and the damage will become apparent after the child reaches puberty.

The Russian National Committee on Non-Ionizing Radiation Protection says that use of the phones by both pregnant women and children should be "limited". It concludes that children who talk on the handsets are likely to suffer from "disruption of memory, decline of attention, diminishing learning and cognitive abilities, increased irritability" in the short term, and that long-term hazards include "depressive syndrome" and "degeneration of the nervous structures of the brain".

5.3 Irreversible infertility

Recent studies confirm that cell phone radiation can drastically affect male fertility. In 2006, the American Society for Reproductive Medicine reported that use of cell phones by men is associated with decrease in semen quality, sperm count, motility, viability and normal morphology and is related to the duration of cell phone use. Studies have found 30% sperm decrease in intensive mobile phone users, in addition to damage of sperms. The average sperm count was found to be at 59 million sperm per milliliter of seminal fluid compared to 83 million for men not continually exposed to mobile phone radiation. Similarly, the study found that motility - the power of the sperm to swim - was affected by mobile phone transmissions. Men who made lengthy calls had fewer rapidly motile sperm, 36.3 per cent compared with 51.3 per cent for men who made no calls.

It was found that not only does using a phone affect a man's sperm quality, but simply having it switched ON in a pocket was enough to do damage as mobile phones periodically but briefly transmit information to cell towers to establish contact. Radiation from cell phone can also produce DNA breaks in sperm cells that can mutate and cause cancer. Damage to sperm DNA increases the risk further and can pass on the genetic changes to subsequent generations.

Animal studies indicate that EMR may have a wide range of damaging effects on the testicular function and male germ. It has been reported that mice on exposure to cell phone signals from an antenna park become less reproductive. After five generations of exposure, the mice were not able to produce offspring, showing that the effect of Radio frequency radiation can pass from one generation to another.

Due to these reasons it is advisable to never wear or use any wireless device near reproductive organs. Men planning to father children are advised to make sure that they stop using wireless devices well in advance of fertilization to reduce the chance of procreation with damaged sperm.

5.4 Calcium ion release from cell membranes

Studies have shown that weak electromagnetic fields remove calcium ions bound to the membranes of living cells, making them more likely to tear, develop temporary pores and leak. Leakage of calcium ions into the cytosol (the fluid found inside cells) acts as a metabolic stimulant, which accelerates growth and healing, but it also promotes the growth of tumors. Leakage of calcium ions into brain cells generates spurious action potentials (nerve impulses) accounting for pain and other neurological symptoms in electro-sensitive individuals. It also degrades the signal to noise ratio of the brain making it less likely to respond adequately to weak stimuli.

5.5 DNA damage

Cellular telephone frequencies can lead to damaged DNA. Studies show that microwave exposure at levels below the current FCC exposure standard, produces single and double strand breaks in DNA. EMR causes membrane leakage due to loss of calcium ions. Leaks in the membranes of lysosomes (small bodies in living cells packed with digestive enzymes) release DNAase (an enzyme that destroys DNA), which explains the fragmentation of DNA seen in cells exposed to mobile phone signals.

Microwave radiation can also interfere with the natural processes involved in DNA replication and repair, by subtly altering molecular conformation (architecture). Another possibility of DNA damage is via free radical formation inside cells. Free radicals kill cells by damaging macromolecules, such as DNA, protein and membrane and are shown to be carcinogenic. Several reports have indicated that electromagnetic fields (EMF) enhance free radical activity in cells as shown in Figure 6. The Fenton reaction is a catalytic process of iron to convert hydrogen peroxides, a product of oxidative respiration in the mitochondria, into hydroxyl free radical, which is a very potent and toxic free radical. Thus EMF affects the DNA via an indirect secondary process.

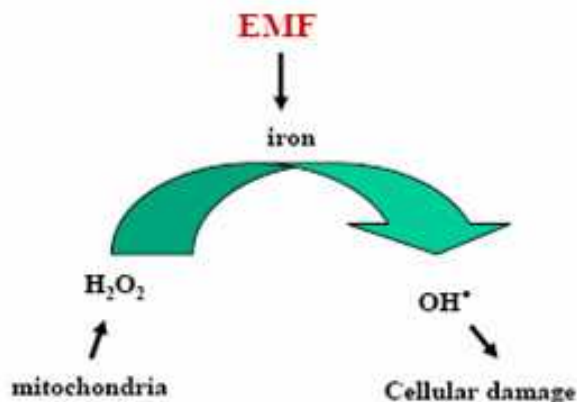


Figure 6 - The Fenton Reaction

Damage to DNA is a central mechanism for developing tumors and cancer. When the rate of damage to DNA exceeds the rate at which DNA can be repaired, there is the possibility of retaining mutations and initiating cancer. DNA damage in brain cells can affect neurological functions and also possibly lead to neurodegenerative diseases.

5.6 Interference with other gadgets including Pace Makers

Cell phone radiation interferes with navigational equipment; therefore its use is banned in airborne flights. Electromagnetic interference (EMI) from mobile phones can cause malfunctioning of life-line electronic gadgets in the hospitals thereby potentially endangering patients. It is also advisable to restrict mobile phone use in clinical areas like operating theatres and intensive care units.

Finally, hospital construction needs to take into account EMR from different areas within the hospital, as well as external sources, to limit interference with medical equipment. For example, allowing mobile phone use in a hospital corridor adjacent to a ward with sensitive medical equipment susceptible to EMR could be problematic.

RF exposure from mobile phones and cellular phone base antennas can also affect patients carrying Pace Maker, Implantable Cardiovascular Defibrillators (ICDs) and Impulse Generators. The signals generated by mobile phones cause electromagnetic interference with the device and interfere with its proper functioning. The signals produced by cell phone operating functions like, turning on, ringing, conversation and turning off, contain components of low frequencies that can interfere with the implanted pacemakers causing them to become arrhythmical which in adverse conditions can put the patient to death.

Due to these reasons government agencies have advised not to place mobile phones directly over pacemakers (such as in the chest pocket) and have issued recommendations to health care providers and patients with pacemakers. Also, the cellular phone should be used with the right ear if the pacemaker is implanted in the left side of the chest. As a safety measure, it is advisable to maintain a safe distance of about 50 cm between portable mobile phones from the patient.

5.7 Effects on Stress Proteins (Heat Shock Proteins)

Non-thermal effects of Radio frequency radiation accumulate over time and the risks are more pronounced after several years of exposure. The effects are not observed in the initial years of exposure as the body has certain defense mechanisms and the pressure is on the stress proteins of the body, namely the heat shock proteins (HSPs). The highly conserved HSPs accumulate in cells exposed to heat and a variety of other stressful stimuli like heavy metal poisoning and oxygen deprivation. HSPs, which function mainly as molecular chaperones, allow cells to adapt to gradual changes in their environment and to survive in otherwise lethal conditions.

It has been observed that GSM mobile phone exposure can activate the cellular stress response in both human and animal cells and cause the cells to produce stress proteins (heat shock proteins), in particular HSP27 and HSP70. This means that the body recognizes these electromagnetic radiations as a potential harm. Hence RF exposures add to the list of environmental stressors that

cause a physiological stress response. This further demonstrates that ELF and RF exposures can be harmful, and it happens at levels far below the existing public safety standards.

HSPs are known to inhibit natural programmed cell death (apoptosis), whereby cells that should have ‘committed suicide’ continue to live. Recent studies show that HSP27 and HSP70 inhibit apoptosis in cancer cells. Taken together, these various effects are, in turn, consistent with the 2 to 3 fold increase in the incidence of a rare form of cancers. If the stress goes on for too long, there is a reduced response, and the cells are less protected against the damage. This is why prolonged or chronic exposures may be quite harmful, even at very low intensities.

5.8 Effect on Skin

Radiation from cell towers and mobile phones affects human skin. People who talk often on cell phones have a higher concentration of the *transthyretin* protein than those who do not. *Transthyretin* is formed in the liver; it helps transport vitamin A in the body and plays an important role in nervous diseases such as Alzheimers.

The symptoms of *Morgellons* disease include those of electromagnetic hypersensitivity (EHS); may be based on how body uses electric currents to repair wounds to the skin. People who suffer from this condition report a range of skin symptoms including crawling, biting and stinging sensations; granules, threads or black speck-like materials on or beneath the skin and/or lesions (e.g., rashes or sores). EMFs degrade the immune system and stimulate various allergic and inflammatory responses. The high radiation from cell towers can result in an increase in mast cells, which explains the clinical symptoms of itch, pain, edema and erythema.

5.9 Tinnitus and Ear Damage

Tinnitus, popularly known as “Ringxiety”- is the psychological disease of hearing phantom sound and sensation of cell phone ring and it has been reported among millions of cell phone users in the world. People with severe tinnitus may have trouble hearing, working or even sleeping. The radiation emitted by mobile phones may damage the delicate workings of the inner ear, and long-term and intensive mobile phone use for more than four years and for longer periods than 30 minutes in a day are at a higher risk of developing hearing loss, which cannot be reversed.

This auditory perception has been shown to occur when a person’s head is illuminated with microwave energy. The microwave pulse upon absorption in the head, launches a thermo-elastic wave of acoustic pressure that travels by bone conduction to the inner ear. There it activates the cochlear receptors via the same process involved for normal hearing, which explains the “clicks” heard by people exposed to microwave radiation.

Today, more and more young people between 18 and 25 years of age are suffering from hearing loss, which doctors say is due to excessive use of mobile phones and other gadgets. Good hearing depends on the health of some 16,000 hair cells present in each inner ear. But increasingly, doctors have been treating people whose hair cells have been damaged by the high radiation emitted from cell phones. Hearing problems occur because these cells do not regenerate. Anyone who spends two to three hours on the cell phone every day runs the risk of

partial deafness over three to five years. Most of the marketing and tele-consulting professionals are in their 20s, and their jobs demand long conversations on cell phones. The problem starts with a pain in the ear that gradually develops into tinnitus or a ringing sensation which finally leads to hearing loss.

5.10 Effect on Eye/ Uveal Melanoma

Frequent use of mobile phones can also damage the visual system in many ways and cause uveal melanoma i.e. tumor of the eye. Tumors involve the choroid (98%), iris (1%) and unknown parts of the uveal tract (1%). Computational modeling and experiments with several laboratory animals show that microwave radiation similar to mobile phone frequencies (900, 1800 MHz and 2450 MHz) can induce chromosomal breaks in the corneal epithelial cells and increase the intraocular temperature of the eye with prolonged exposure.

Increase in temperature close to the eye lens (as low as 3°C) can result in lens opacities and increase the risk of developing cataracts in humans, a condition characterized by clouding in the natural lens of the eye and lens opacities. When Bovine eye lenses were exposed to microwave radiation, it caused macroscopic damage and affected the optical function of the lens. The damage increased as the irradiation continued and reached a maximum level after a number of days. When the exposure stopped the optical damage began to heal gradually. A similar maximum level was observed when the irradiation intensity was reduced to one-half the original, except that it took twice the time. A lens of good optical quality is able to focus the laser beam from the various locations (green lines in the left frame of Fig. 7. When the lens is damaged due to exposure to microwave radiation, its ability to focus the laser beam at the various locations is altered, as clearly revealed in the right frame. The blue line connects the points of the back vertex distance for each ray passing through the lens. The pink line shows the relative intensity of each beam, that is, the transmitted intensity normalized to the incident one.

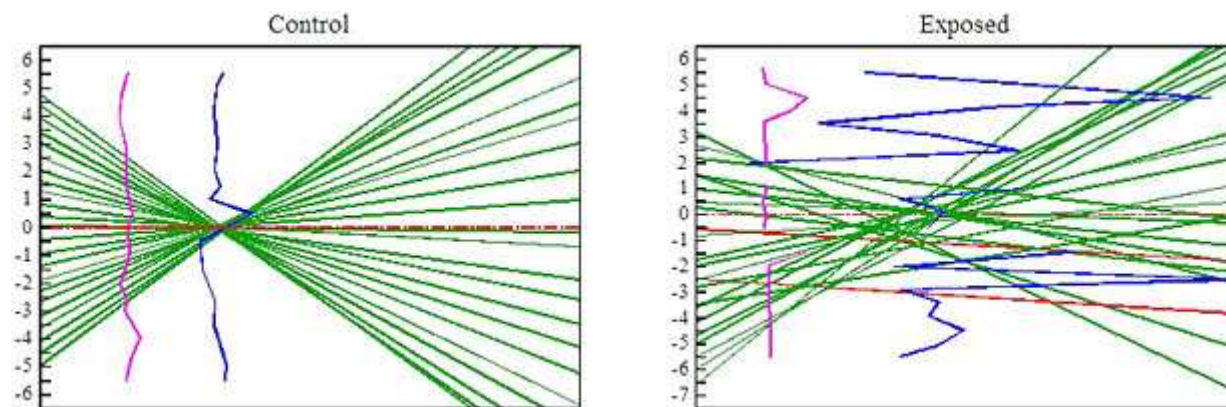


Fig. 7 – Left - Good quality lens - all rays passing through the lens have similar focal length. Right - Exposed lens, showing considerable variability in the focal length of the beams passing through the lens.

Prolonged exposure to microwave radiation similar to that used by cellular phones can lead to both macroscopic and microscopic damage to the lens and part of this damage seems to accumulate over time and does not heal.

5.11 Cell phone emission weaken bones

Researchers have measured bone density at the upper rims of the pelvis (iliac wings) in men who were mobile users and carried their phones on their belts. The iliac wings are widely used source of bone for bone grafting, so any reduction in bone density may be of special importance to reconstructive surgery. The results showed reduction in iliac wing bone density on the side where men carried their phones. In general, it is better to keep mobile phones as far as possible from our body during our daily lives.

5.12 Salivary gland tumor

Increased risk of salivary gland cancer among residents in Israel from 1970 to 2006 has been reported, which is believed to be linked to the use of mobile phones. Among salivary gland cancer cases, researchers found a worrying rise in the number of cases of malignant growth in parotid glands - the salivary gland located under the ear, near the location where cell phones are held during conversations. Users below the age of 20 were found to be more susceptible.

Another epidemiology study found that people who held a mobile handset against one side of their head for several hours a day have 50% more risk for tumor formation in the parotid gland - the largest salivary gland after 5-10 years.

5.13 Melatonin Reduction

Melatonin, a vital natural neuro-hormone is a powerful antioxidant, antidepressant and immune system enhancer that regulates our circadian rhythm. Every night as we go to sleep, our melatonin levels rise. Melatonin goes through our blood and clears our cells up, that is to say, scavenges free radicals in the cell to protect the DNA and reduce the possibility of cells becoming carcinogenic. The daily sleep/wake cycle, blood pressure and heart rate cycle, metabolic rate and thermal regulation, hormone production and immune system activity all have a daily cycle regulated by melatonin directly or indirectly through the autonomic system.

Various studies show that exposure to EMR reduce melatonin levels in animals and humans. Daily cellular telephone use of >25 minutes over years may lead to reduced melatonin production. Studies with animals show a reduction in melatonin levels following radiofrequency radiation exposure from cell phones and cell sites. Turning off the transmitters resulted in a significant increased melatonin levels within few days.

When availability of melatonin is impaired, a whole range of disorders including sleep disturbance, chronic fatigue, depression, cardiac, reproductive and neurological diseases and mortality can occur. Reduced melatonin is also associated with increased DNA damage and increased risk of cancer, arthritis, seasonally affective disorder (SAD), schizophrenia, increased eye stress, renal impairment, Alzheimer's and Parkinson's disease, miscarriage, sudden infant death syndrome (SIDS), and increased risk of childhood leukemia.

5.14 Sleep Disorders

Electromagnetic fields have been shown to affect the brain physiology. Use of mobile phones disturbs Stage 4 sleep, the stage important for full recuperation of brain and body. Use of the handsets before bed, delays and reduces sleep, and causes headaches, confusion and depression. The findings are especially alarming for children and teenagers as they use cell phones at night and also keep the phone next to their head; which may lead to mood and personality changes, depression, lack of concentration and poor academic performance.

The relationship of sleep disturbance with exposure to a cell phone/ tower radiation is shown in Fig. 8. It can be seen that percentage increase in sleep disturbance is proportional to the exposure dose. Even at $1\text{ nW/cm}^2 = 0.001\mu\text{W/cm}^2 = 10\mu\text{W/m}^2$, disturbance in the sleep is of the order of 35%. When the transmitter was turned off, the symptoms resumed gradually

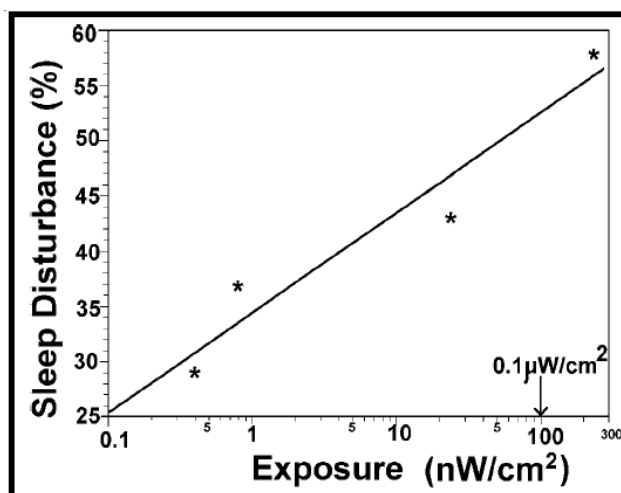


Figure 8 - Dose-response relationship for Sleep Disturbance with exposure in nW/cm²

5.15 Neurodegenerative Diseases

Exposure to electromagnetic fields has shown to be in connection with Alzheimer's disease, motor neuron disease and Parkinson's disease. All these diseases are involved with the death of specific neurons and are classified as neurodegenerative diseases.

People living near mobile phone base stations are also at risk for developing neuropsychiatric problems as headache, memory loss, nausea, dizziness, tremors, muscle spasms, numbness, tingling, altered reflexes, muscle and joint pain, leg/foot pain, depression, and sleep disturbance. More severe reactions include seizures, paralysis, psychosis and stroke.

5.16 Increase in Cancer risk

Heavy use of mobile phones can cause cancer. Use of mobile phones for >10 years give a consistent pattern of increased risk for brain cancer - glioma (cancer of the glial cells that support the central nervous system) and acoustic neuroma (a benign tumor in the brain on a nerve

related to hearing). The risk is highest for ipsilateral (on the same side of the head where the instrument is held) exposure. Children and teenagers, before the age of 20 are five times more likely to get brain cancer, as their brain is not fully developed and radiation penetration is much deeper. It is possible that today's young people may suffer an "epidemic" of the disease in later life.

Besides increase in brain tumour and acoustic neuroma, there is an increased risk of several other types of cancers following prolonged exposure to mobile phone/ tower radiation, such as, salivary gland tumors, uveal melanoma, lymphoma, facial nerve tumors, skin, blood, testicular and breast cancer. Interphone study has also found a 'significantly increased risk' of some brain tumors for heavy users of mobile phones (> 20 minutes per day) for a period of 10 years or more. It is suggested that children should be discouraged from using mobile phones and restrict use to emergency while adults should "keep calls short".

5.17 Epidemiological studies in various countries

There have been several epidemiological studies of people living near cell phone antennas in Spain, the Netherlands, Israel, Germany, Egypt, Austria, etc. All these studies documents adverse health effects and exposures are orders of magnitude below the FCC or ICNIRP guidelines. Some of these studies are summarized below:

Example 1: FRANCE (Santini, 2002)

In this study the people who lived closest to the cellular antennas had the highest incidences of the following disorders: fatigue, sleep disturbances, headaches, feeling of discomfort, difficulty in concentrating, depression, memory loss, visual disruptions, irritability, hearing disruptions, skin problems, cardiovascular disorders, and dizziness (See Figure 9).

Women were found to have more symptoms than men. This study, based on the symptoms experienced by people living in vicinity of base stations recommend that the cellular phone base stations should not be sited closer than 300 m to populations. This is probably not possible in Urban area, so the solution is to reduce the transmitted power level.

Example 2: GERMANY (Eger H, 2004)

The aim of this study was to examine whether people living close to cellular transmitter antennas were exposed to a greater risk of becoming ill with malignant tumors. The researchers found that the proportion of newly developing cancer cases was significantly higher among those patients who had lived within **400 meters** from the cellular transmitter site during the past 10 years, compared to those patients living further away. They also found that the patients fell ill on average 8 years earlier. After five years of operation of the transmitting installation, the relative risk of getting cancer had increased by 3-fold for the residents of the area near the installation, compared to the inhabitants outside the area. Breast cancer topped the list, and the average age of contracting this disease was considerably lower, 50.8 years compared to 69.9 years for the people living in the outer area. Cancers of the prostate, pancreas, bowel, skin melanoma, lung and blood cancer were all increased.

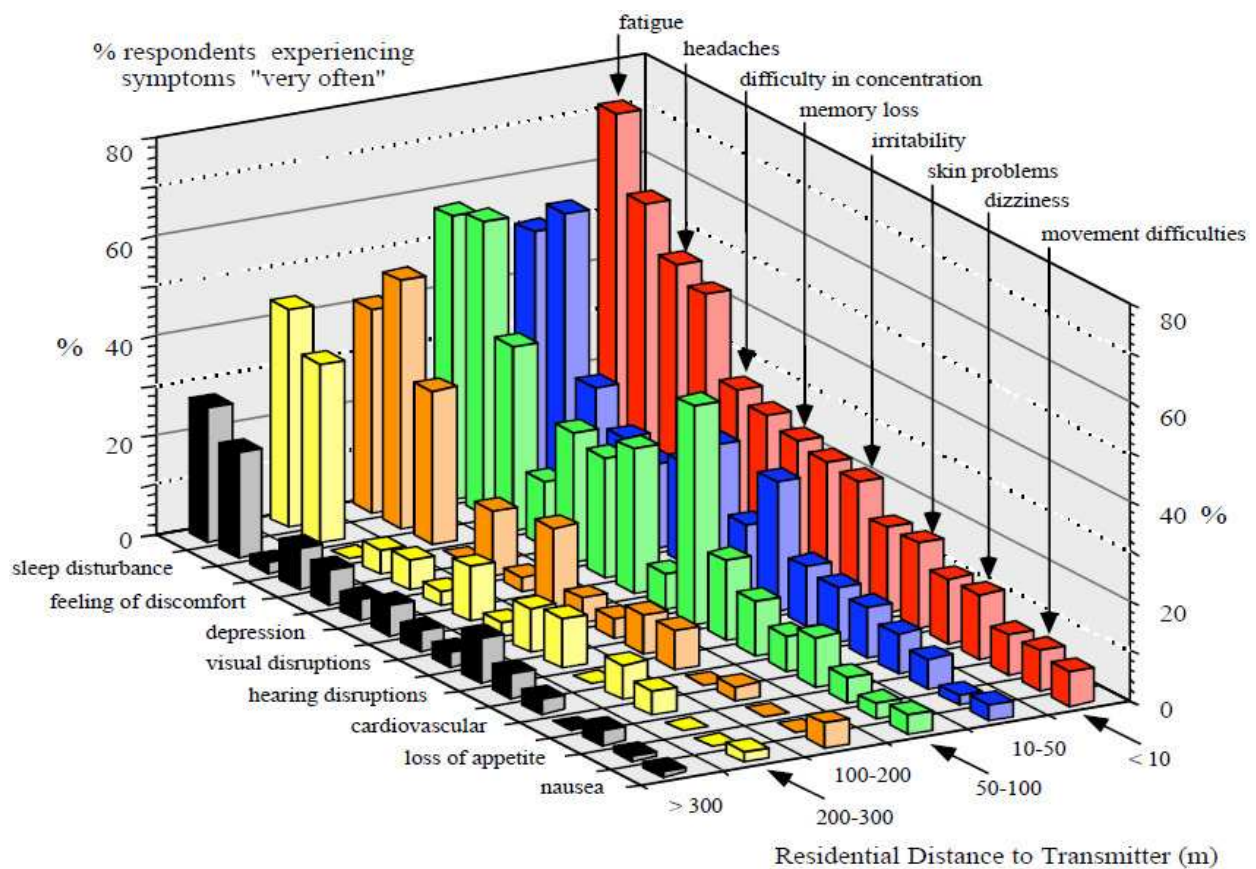


Figure 9. Response of residents living in the vicinity of a cellular phone base station in France.

Example 3: ISRAEL (Wolf R, Wolf D, 2004)

This study, based on medical records of people living within 350 meters of a long established phone mast, showed a fourfold increased incidence of cancer compared with the general population of Israel, and a tenfold increase specifically among women, compared with the surrounding locality further from the mast.

Example 4: SPAIN (Oberfeld 2004)

This study found significant ill-health effects among those living in the vicinity of two GSM mobile phone base stations. The strongest five associations found were depressive tendency, fatigue, sleeping disorder, difficulty in concentration and cardiovascular problems. The scientists reported the following symptoms within 50 to 150 m of the cell phone antenna at an average power density of $0.11 + 0.19 \mu\text{W}/\text{cm}^2$. Note that $0.11 \mu\text{W}/\text{cm}^2$ is considerably lower than $1000 \mu\text{W}/\text{cm}^2$ established by the FCC. This demonstrates that the FCC guideline does not protect the public from radio frequency radiation exposure.

Among the 350 inhabitants of Pérez, near the town of Velez-Malaga, there have been 43 cases of cancer, 35 of which have resulted in death.

Example 4: SWEDEN

Sweden was one of the first countries to claim 100% mobile connectivity. Survey studies show that somewhere between 230,000 - 290,000 Swedish men and women out of a population of 9,000,000 are now electrohypersensitive (EHS) and report a variety of symptoms when being in contact with electromagnetic field sources. Symptoms include - allergic reactions, redness of skin, memory loss, sleep disruption, headache, nausea, tingling, altered reflexes, buzzing in the head, palpitations of the heart, visual disorders, cardiovascular problems, respiratory problems etc. Severe symptoms like leukemia, brain cancer, and acoustic neuroma (tumor in the ear) have also been reported. Sweden is the only country in the world to recognize EHS as a functional impairment/ physical degradation and not a disease.

Example 5: UK

In Berkeley House, Staple Hill, Bristol, UK, where Orange mobile mast was erected on roof of a five story building; several people living on the top floor had cancer.

In Warwickshire, 31 cancer patients were detected on a single street and a quarter of 30 odd staff at a special school, within sight of 90 ft high mast, developed brain tumors since 2000. The masts are being pulled down under growing protests of thousands of people.

Example 5: Australia

The top floors of a Melbourne office building were closed down and 100 people were evacuated after a seventh worker in seven years was diagnosed with a brain tumour. The Australian Health Research Institute indicates that due to billions of times more in volume electromagnetic radiation emitted by billions of mobile phones, internet, intranet and wireless communication data transmission, almost one-third of world population (about 2 billion) may suffer from Cell Phone Cancer beside other major body disorders like heart ailments, impotency, migraine, epilepsy by 2020

Example 6: India:

Builder in Riddhi Park, Thakurlee (West) had installed mobile tower before the residents had occupied the building. Within 4 months of occupying the top floor flat, Mrs. Bhat was diagnosed with “brain tumor”. She used to feel fatigued; and also suffered from white rashes on the body. Her neighbor delivered a baby with cancer of spinal cord. Another neighbor gave birth to a child having “Birth Defects”; and the child died immediately after birth. All the residents of the building are now demanding the demolition of the tower. In spite of these demands by residents, builder has installed another tower. Mrs. Bhat has left her flat now staying in Goregaon and spent around Rs. 10 lakhs for treatment on brain tumor. However her health is now improving.

Mr. Bhagwant Deshpande of Solapur has reported 9 deaths due to cancer living within 91m from the two towers. Details of the dead people are given below:

Name of deceased	Year of death	Cause of death	Age at time of death
Radhabai Sathe	2005	Breast cancer	66
Deshpande	2006	Oesophagus cancer	48
Shubhangee Deshpande	2007	Rectum cancer	66
Pujaree	2008	Cancer	46
Gawai	2008	Breast cancer	52
Shah	2009	Cancer	48
Vidyadhar Dev	2009	Liver cancer	52
Ransube	2009	Throat cancer	73
Archana Malvadkar	2009	Spinal cord cancer	17

Source: L B Deshpande, who studied the deaths in his Solapur locality since two towers were installed four years ago

6. Adverse effect on birds, animals and environment

Electromagnetic radiation from Cell phone and cell tower affects the birds, animals, plant and environment. One would never see a bee, sparrow, pigeon, or any bird flying and staying near the cell tower? The reason is that surface area of a bird is relatively larger than their weight in comparison to human body, so they absorb more radiation ($\text{power} = \text{power density} \times \text{area}$). Since fluid content is small due to less weight, it gets heated up very fast and also the magnetic field disturbs their navigational skills. These effects are given in the following sub-sections.

6.1 Effect on Honey Bees

It has been quoted that Albert Einstein had said, “If the bee disappears from the surface of the earth, man would have no more than four years to live.” In the US, an abrupt disappearance of bees was observed several years back and was associated with the rising electromagnetic pollution. This is known as Colony Collapse Disorder (CCD) where bees cannot find their way back to the hive as a result of consistent electromagnetic back ground noise that seems to disrupt intercellular communication within individual bees. CCD has since spread to Germany, Switzerland, Spain, Portugal, Italy, Greece, Scotland, Wales and north-west England. In England, the bee population fell by 54 percent between 1985 and 2005 compared to an average of 20 per cent across Europe.

Recently, a sharp decline has also been noticed in commercial bee population in Kerala posing a serious threat to honey bees, hitting apiculture (the cultivation of bees on a commercial scale for the production of honey). The State has the highest density of mobile towers. Similar cases have been observed in Bihar, Punjab, Nepal and other parts of India and have been attributed to increasing electro pollution in the environment.

When honey bee colonies were exposed with radiation, the honeycomb weight and area were reduced and returning time of honey bees increased compared to similar non-exposed colonies. Several other studies show that the high-frequency electromagnetic fields of mobile phones alter the resonant stimulus of living organisms and can cause modifications in certain areas of their brain. Changes in the brain structure of bees can be a cause of alterations of the returning capabilities of bees.

It's not just the honey that will be lost if populations plummet further. Bees are estimated to pollinate 90 commercial crops worldwide. The current dying/vanishing of honey bees can have serious consequences for human health. Scientists warn that the steady decline in bees and other pollinators could trigger crises bigger and more immediate than global warming.

Honey bees brain anatomy as well as the learning regions of the bee brain are well known and comparable to those of vertebrates and are well suited as a bio-indicator. We are fortunate that the warning bells have been sounded and it is for us to timely plan strategies to save not only the bees but human life and environment from the ill effects of such EMR.

6.2 Effect on Birds

When birds are exposed to weak electromagnetic fields, they disorient and begin to fly in all directions, which explain migratory birds undermining navigational abilities. A large number of birds like pigeons, sparrows, swans are getting lost due to interference from the new "unseen enemy", i.e. mobile phone masts. Several million birds of 230 species die each year from collisions with telecommunications masts in the United States during migration. Accidents happen mainly in the night, in fog, or bad weather, when birds might be using the earth's magnetic field for navigation, and could be seriously disoriented by the microwave radiation from telecommunication masts.

During recent decades there has been a marked decline of the house sparrow population. London has witnessed a steep fall in its sparrow population; a 75 per cent fall since 1994. There have been dramatic declines, almost to the point of extinction in Glasgow, Edinburgh, Hamburg, Ghent, Brussels, Dublin, Belgium, etc. Studies show that the disappearance of the sparrow and the introduction of phone mast GSM towers correlate closely in terms of time.

In Spain, to monitor the breeding success of the white stork population, 60 nests were selected and visited from May to June of 2003. Thirty nests were located within 200 m of mobile masts and other 30 were located at a distance of more than 300 m from any transmitter. 40% of the nests close to the antennae were without young, as opposed to 3.3% among those at a larger distance. Behavioural changes were also observed among birds close to the phone antennae. Young birds died from unknown causes and bird couples frequently fought while constructing their nests. Some nests were never completed and the storks remained passively in front of the antennae.

Microwaves from phone masts also interfere with reproductive success of birds. In an experiment, 75% of chicken embryos that were exposed to a GSM mobile phone during incubation died compared to 16%, who were not exposed to any radiation. Birds having nest near

towers were found to leave their nests within one week. The eggs laid in nests near towers failed to hatch.

A general disappearance of birds like Kestrel, White Stork, Rock Dove, pigeons, Magpie has been observed near base stations for mobile telecommunication. Locomotive problems, breeding problems, and tendency to stay long in lower parts of the trees and on the ground have been observed. In some tracked nests (blackbird), the eggs never hatched and also many dead specimens were found near phone masts areas.

A house sparrow is associated with human habitation. Being very sensitive to changes in the environment, it is one of the most preferred indicator species of urban ecosystems. A stable house sparrow population indicates a healthy ecosystem for human beings in terms of air and water quality, vegetation and other parameters of habitat quality. Whereas, a declining population of the bird provides a warning that the urban ecosystem is experiencing some environmental changes unsuitable for human health in the immediate future.

6.3 Effect on mammals and amphibians

The study in Germany showed that cows grazing near cell towers are more likely to experience still births, spontaneous abortions, birth deformities, behavioral problems and general declines in overall health. Moving cattle herds away from such towers has reportedly led to immediate health improvements. Exposing dairy cows to magnetic fields can also result in reduction in milk yield, changed milk composition and fertility problems. Recently, a significant increase of micronuclei in erythrocyte in the blood of cattle grazing on a farm near a transmitting facility was discovered. This is an indication of a genotoxic effect of the exposure, which means the change will pass on to their subsequent generations.

Similarly, impaired immune system in sheep, reproductive and developmental problems in dogs and cats, anxiety and alarm in rabbits, frequent death of domestic animals such as, hamsters, and guinea pigs living near base stations of mobile telecommunication towers has been observed.

Electromagnetic pollution is a possible cause for deformations and decline of some amphibian populations too. Morphological abnormalities, allergies, changes in blood counts, increase in the heart rate, arrhythmia and increased mortality has been found in amphibians like Newts and frog tadpoles. Bat activity is significantly reduced in habitats exposed to electromagnetic field. During a study, in a free-tailed bat colony, the number of bats decreased when several phone masts were placed 80m from the colony.

6.4 Effect on Plants

Apart from bees, birds and animals, electromagnetic radiation emanating from cell towers can also affect vegetables, crops and plants in its vicinity. Studies show definitive clues that cell phone EMF can choke seeds, inhibit germination and root growth, thereby affecting the overall growth of agricultural crops and plants. A reduction in wheat and corn yield in the fields near high EMF lines has also been reported.

Progressive deterioration of trees near phone masts has also been observed. Trees located inside the main lobe (beam), look sad and feeble, have dried tops, show slow growth and high susceptibility to illnesses and plagues. Also, electromagnetic radiations generate heat. Due to this, the microorganisms present in the soil near it would be killed. This in turn harms those organisms which feed on them and disturbs the ecological cycle.

7. Possible Solutions to reduce the ill effects of cell tower radiation

There are several health hazards due to radiation from the cell towers to the human, birds, animals and environment. In India, we have adopted very relaxed radiation norms of 4.7 W/m^2 for GSM900, whereas serious health effects have been noted at as low as $0.0001 \text{ W/m}^2 = 100 \mu\text{W/m}^2$. One of the first steps to be taken is to tighten the radiation norms and yet it should be practical enough to be cost effective without causing too much inconvenience to the users. It is recommended that maximum cumulative power density allowed should be reduced with immediate effect to 0.1 W/m^2 , which should then be subsequently reduced to 0.01 W/m^2 within a year, so that network planning can be carried out in a phased manner. It must be noted that a few countries have even adopted 0.001 W/m^2 or lower, so our proposed recommendation is higher than these countries to keep it cost effective. All the operators must be strictly instructed that power density inside residential or office buildings, schools, hospitals, and at common frequently visited places should be within these guidelines. People must be informed about the harmful radiation effects and corrective measures taken by Govt. of India. Also, people must be informed that for some time, they may have network problem (especially people living far away from the cell tower) due to reduction in the transmitted power but it is for their overall health benefit.

Solution is to have more numbers of cell towers with lesser transmitted power. When power transmitted is reduced, it will not require power hungry power amplifiers having lower efficiency. Heating effect will also be reduced, so lesser cooling or no cooling will be required; all of these will reduce the power requirement, which can also be met by solar panel. Thus, high power diesel generators will also be not required; it will reduce the carbon emission and we can earn from carbon credits.

In addition, repeaters or signal enhancers or boosters may have to be installed where signal is weak. Care must be taken that maximum power transmitted by these must not exceed 0.1 W because of their close proximity to the users.

Self certification by the operators must be immediately abolished; measurements must be done by third party, which is independent and trustworthy. Also, radiation measurements must be monitored continuously, so that operators should not increase the transmitted power during the peak period. Very strict penalties must be imposed on those operators, who violate these norms as it causes serious health hazards to innocent people.

The reduction in the transmitted power for the above solutions will definitely increase the installation and maintenance cost, because of this reason, operators all over the world are claiming that there are no radiation health hazards. Increase in the cost of deployment of network can be met by increasing per minute charges from Rs. 0.30 to 0.35, extra carbon credits earned,

etc. Also, Govt. may consider reducing the tax or license fee in the overall interest of saving the lives of people, birds, animals, plants, and environment, thereby saving mother earth.

8. Conclusion

The seriousness of the health hazards due to radiation from the cell phones and cell towers has not been realized among the common man. Cell operators continue to claim that there are no health issues. Even organizations like WHO, ICNIRP, FCC, etc. have not recommended stricter safe radiation guidelines, whereas several countries have adopted radiation norms, which are $1/100^{\text{th}}$ to $1/1000^{\text{th}}$ of these values based on their studies. Cell phone industry is becoming another cigarette industry, which kept claiming that smoking is not harmful and now there are millions of people around the world who have suffered from smoking. In fact, cell phone/tower radiation is worse than smoking; as one cannot see it or smell it, and its effect on health is noted after a long period of exposure. Therefore, majority of people tend to have casualness towards personal protection. Unfortunately, ignorance and non-awareness adds to this misery and all of us are absorbing this slow poison unknowingly. Even if people are aware of the radiation hazard, they may not have the choice to move away from it if the tower is installed near their office or residential building.

In addition to the continuous radiation from cell towers, there is radiation from cell phones, wireless phones, computers, laptops, TV towers, FM towers, AM towers, microwave ovens, etc. We are exposed to all these radiations which are additive in nature. Hence, it is imperative that stricter radiation norms must be enforced by the policy makers.

This does not mean that we have to stop living near these towers. We all know that automobiles create air pollution – have we stopped using them? Instead, solutions were found such as unleaded petrol, catalytic converters to reduce emission, CNG driven vehicles, hybrid vehicles, etc. If people in the mobile companies think there is no health hazard, then let them stand in front of their own transmitting tower at 1m distance in the main beam for 6 hours – are they willing to take the risk? Similar effect will be there at 10m distance in about 600 hours (25 days). If mobile companies accept that radiation causes serious health problems, will people stop using cell phones? Not really, because the cell technology has its several advantages. However, then researchers/technocrats/entrepreneurs will come out with possible solutions, which may be expensive but that cannot be greater than the health risk faced by humans, birds, animals and environment.

Appendix A – Conversion from power received to electric field and power density

Power Density S can be calculated from the following equation in W/m²

$$S = \frac{P \cdot 4\pi \cdot f^2}{c_0^2 \cdot G_i}$$

where,

P Measured Power in W (Example: P= -30dBm = 0.000001W)

G_i Gain of receiving antenna

f Frequency in Hz

c₀ Velocity of light = 3 x 10⁸ m/s.

Following table gives values of electric field and power density for an isotropic antenna G_i = 1 for different values of power received.

Conversion table

Conversion between units: dBm to V/m, W/m			Conversion between units: dBm to V/m, W/m		
0 dBm	6,75V/m	0,121W/m ²	-36dBm	0,107V/m	0,000.030.4W/m ²
-1 dBm	6,02V/m	0,096.0W/m ²	-37dBm	0,095.4V/m	0,000.024.1W/m ²
-2 dBm	5,36V/m	0,076.3W/m ²	-38dBm	0,085.0V/m	0,000.019.2W/m ²
-3 dBm	4,78V/m	0,060.6W/m ²	-39dBm	0,075.8V/m	0,000.015.2W/m ²
-4 dBm	4,26V/m	0,048.1W/m ²	-40dBm	0,067.5V/m	0,000.012.1W/m ²
-5 dBm	3,80V/m	0,038.2W/m ²	-41dBm	0,060.2V/m	0,000.009.60W/m ²
-6 dBm	3,38V/m	0,030.4W/m ²	-42dBm	0,053.6V/m	0,000.007.63W/m ²
-7 dBm	3,02V/m	0,024.1W/m ²	-43dBm	0,047.8V/m	0,000.006.06W/m ²
-8 dBm	2,69V/m	0,019.2W/m ²	-44dBm	0,042.6V/m	0,000.004.81W/m ²
-9 dBm	2,40V/m	0,015.2W/m ²	-45dBm	0,038.0V/m	0,000.003.82W/m ²
-10dBm	2,13V/m	0,012.1W/m ²	-46dBm	0,033.8V/m	0,000.003.04W/m ²
-11dBm	1,90V/m	0,009.60W/m ²	-47dBm	0,030.2V/m	0,000.002.41W/m ²
-12dBm	1,70V/m	0,007.63W/m ²	-48dBm	0,026.9V/m	0,000.001.92W/m ²
-13dBm	1,51V/m	0,006.06W/m ²	-49dBm	0,024.0V/m	0,000.001.52W/m ²
-14dBm	1,35V/m	0,004.81W/m ²	-50dBm	0,021.3V/m	0,000.001.21W/m ²
-15dBm	1,20V/m	0,003.82W/m ²	-51dBm	0,019.0V/m	0,000.000.960W/m ²
-16dBm	1,07V/m	0,003.04W/m ²	-52dBm	0,017.0V/m	0,000.000.763W/m ²
-17dBm	0,954V/m	0,002.41W/m ²	-53dBm	0,015.1V/m	0,000.000.606W/m ²
-18dBm	0,850V/m	0,001.92W/m ²	-54dBm	0,013.5V/m	0,000.000.481W/m ²
-19dBm	0,758V/m	0,001.52W/m ²	-55dBm	0,012.0V/m	0,000.000.382W/m ²
-20dBm	0,675V/m	0,001.21W/m ²	-56dBm	0,010.7V/m	0,000.000.304W/m ²
-21dBm	0,602V/m	0,000.960W/m ²	-57dBm	0,009.54V/m	0,000.000.241W/m ²
-22dBm	0,536V/m	0,000.763W/m ²	-58dBm	0,008.50V/m	0,000.000.192W/m ²
-23dBm	0,478V/m	0,000.606W/m ²	-59dBm	0,007.58V/m	0,000.000.152W/m ²
-24dBm	0,426V/m	0,000.481W/m ²	-60dBm	0,006.75V/m	0,000.000.121W/m ²
-25dBm	0,380V/m	0,000.382W/m ²	-61dBm	0,006.02V/m	0,000.000.096.0W/m ²
-26dBm	0,338V/m	0,000.304W/m ²	-62dBm	0,005.36V/m	0,000.000.076.3W/m ²
-27dBm	0,302V/m	0,000.241W/m ²	-63dBm	0,004.78V/m	0,000.000.060.6W/m ²
-28dBm	0,269V/m	0,000.192W/m ²	-64dBm	0,004.26V/m	0,000.000.048.1W/m ²
-29dBm	0,240V/m	0,000.152W/m ²	-65dBm	0,003.80V/m	0,000.000.038.2W/m ²
-30dBm	0,213V/m	0,000.121W/m ²	-66dBm	0,003.38V/m	0,000.000.030.4W/m ²
-31dBm	0,190V/m	0,000.096.0W/m ²	-67dBm	0,003.02V/m	0,000.000.024.1W/m ²
-32dBm	0,170V/m	0,000.076.3W/m ²	-68dBm	0,002.69V/m	0,000.000.019.2W/m ²
-33dBm	0,151V/m	0,000.060.6W/m ²	-69dBm	0,002.40V/m	0,000.000.015.2W/m ²
-34dBm	0,135V/m	0,000.048.1W/m ²	-70dBm	0,002.13V/m	0,000.000.012.1W/m ²
-35dBm	0,120V/m	0,000.038.2W/m ²			

dBm = decibel milliwatts, W/m² = watts per square meter, V/m = volts per meter, A/m amperes per meter

Appendix B - Videos on Radiation

- **Cell Phone Antennas on Apartment Rooftops and their Health Effects**
<http://www.youtube.com/watch?v=-G3CWrgDS5E>
Woman experiences illness after two months of cell phone antennas installed on roof top
- **Phone tumour**
<http://au.video.yahoo.com/watch/8546044/22969162>
Anna , 27, and her doctor convinced that her brain tumour is due to heavy mobile use.
- **New evidence in mobile phone tumour link**
http://www.youtube.com/watch?v=fMZhkDEsXU8&feature=player_embedded
David,30,developed tumour the size of gulf ball behind right ear where he held his phone.
- **Cell phone towers in cities health hazards?**
http://www.youtube.com/watch?v=IOc99xpiy2E&feature=player_embedded
Mrs. Bhatt, brain aneurysm patient, blames the cell phone tower for her problem.
- **Cell phone antennas blamed for kindergarten cancer cases, Chicago**
http://www.youtube.com/watch?v=BrQ9uXv57_s&feature=youtu.be
3 students died of leukemia and 30% of staff sick
- **EMF RF Exposure from cell phone radiation is potentially harmful**
<http://www.youtube.com/watch?v=BXn8c41ZVTQ>
Sarah Dacre, suffers from EHS and wears special shielded clothes to protect herself
- **Health danger - wifi radiation - 2 –**
<http://www.youtube.com/watch?v=EykTJJMvjCs>
Lady lives in a room with Silver foiling
- **Growing Evidence That Cell Phones Create Tumors**
http://www.youtube.com/watch?v=-9DuCzGLohc&feature=player_embedded
Alan,57, developed a gulf ball size tumour on right side of brain where he held his phone.
- **Dr. Charlie Teo - "explosion" in brain tumours and truth about the wireless society**
http://www.youtube.com/watch?v=Zq340oQPfK4&feature=player_embedded#!
John developed malignant tumour behind right ear; Dr. Teo's (neurosurgeon) testimony
- **Cell Phones & Cigarettes: What do they have in Common?**
<http://www.youtube.com/watch?v=K4uz2TUcwnI>
- **Live Blood & Electrosmog -** <http://www.youtube.com/watch?v=L7E36zGHxRw>
- **Street protests against Mobile masts in Taiwan –** <http://bit.ly/a2JNnZ>
- **Mumbai highly unsafe due to heavy mobile tower radiation but VVIPs house is safe**
<http://www.youtube.com/watch?v=JCN9FLSvwhQ&feature=youtu.be> - IN HINDI
- **The National Cell Phones and Disease Sept 26 2010**
http://www.youtube.com/watch?v=F4bp7Zi_8pk
Facts and fine prints about cell phone use
- **Invisible Dangers of Cell Phone Radiation**
<http://www.youtube.com/watch?v=eVo2maA7h1E>
- **Dr Magda Havas - On Cell /Transmission Towers and Your Health**
<http://video.google.ca/videoplay?docid=6284020723745580379#>
- **Cell Phones and Brain Cancer - The Interphone Study**
<http://www.youtube.com/watch?v=npK5HSxukyA>
Interphone witnesses testified about research into cell phone use and its impact on health

More reports and videos have been uploaded at Blog: <http://neha-wilcom.blogspot.com> and Twitter: https://twitter.com/wilcom_neha

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