

**REPORT
ON
CELL PHONE TOWERS RADIATION
HAZARDS**

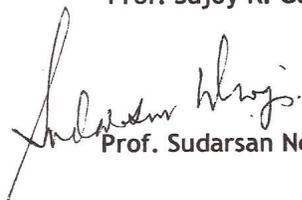
Submitted to

**WEST BENGAL ENVIRONMENT MINISTER
DR. SUDARSAN GHOSH DASTIDAR**

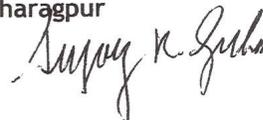
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OCTOBER 2011

Cell Phone Towers Radiation Hazards

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1. Introduction

Cell phone technology has several advantages and has grown rapidly in the last decade. In India, there are nearly 80 crores cell phone subscribers and around 4.5 lakhs cell phone towers. Numbers of cell phones and cell towers are increasing without considering its disadvantages. All over the world, people have been debating about associated health risks due to electromagnetic radiation from cell phones and cell towers. There are several reports in the media and scientific literature, which are conflicting in nature. In West Bengal, cell towers are mushrooming all over the places. People have been complaining to West Bengal Pollution Control Board and other agencies regarding electromagnetic radiation from cell towers, structural stability, noise and air pollution from Diesel Generators (DG), etc. The new West Bengal Government, which came into power in May 2011 and happens to be people friendly, decided to look into cell phone towers radiation hazards in a scientific manner.

A meeting was held on June 19, 2011, Sunday at Paribesh Bhavan, West Bengal Pollution Control Board (WBPCB), Kolkata in the presence of Environment Minister Dr. Sudarsan Ghosh Dastidar, the Principal Secretary, Mr. Raj Pal Singh Kahlon IAS and other officers of WBPCB. The meeting was also attended by Prof. Girish Kumar of IIT Bombay, Prof. Sujoy K Guha and Prof. Sudarsan Neogi of IIT Kharagpur. After several hours of discussion, it was decided to form a technical advisory committee consisting of Professors of IIT Kharagpur and IIT Bombay. Objective of the committee was to assess the scientific findings and put forward recommendations that will be scientifically oriented and will be more protective against electromagnetic radiation by the Cell Phone Towers.

The first meeting of the technical advisory committee was held on the same day, i.e., June 19, 2011 at Paribesh Bhavan. The committee deliberated the matter in detail and came out with the following work plan at the outset.

1. The existing Cell Phone providers having installed the towers will be asked to provide the following technical details in regard to the operating parameters of the installed towers for scientific evaluation.
 - a. Peak power/frequency from each Antenna
 - b. RF amplifier Model and its specification
 - c. Type of Antenna and its radiation pattern
 - d. Land clearance requirement around a tower

2. Electromagnetic radiation emerging from the cell phone towers at various locations in Kolkata will be mapped.

Subsequently, letters were sent to various operators in Kolkata to submit above information. The committee had several meetings at IIT Kharagpur and Kolkata, met various Government officials, analyzed information received from several operators, carried out radiation measurements at several place in Kolkata and Kharagpur, exchanged large number of emails and phone calls, and finally prepared the report with the consent of all the members.

2. Radiation from cell phones

Even though the objective of the committee was to assess the scientific findings regarding electromagnetic radiation from the cell phone towers, it was felt that committee must also look into the effects of radiation from cell phones as these are cumulative in nature. Radiation effects are divided into thermal and non-thermal effects. Thermal effects are similar to that of cooking in a microwave oven and can be calculated by using well established equations. Non-thermal effects are not well defined and there are plenty of controversial findings, but generally, it has been reported that non-thermal effects are a few times more harmful than thermal effects.

A cell phone transmits 1 to 2 Watt of power in the frequency range of 824 to 849 MHz (CDMA), 890 to 915 MHz (GSM900), 1710 to 1780 MHz (GSM1800) and 1920 – 1980 MHz (3G). Radiation from cell phone is defined by its SAR (Specific Absorption Rate) value. In USA, SAR limit for cell phones is 1.6W/Kg, which is actually for 6 minutes per day use. 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. Majority of the people have reported that if they use cell phones for more than 20 minutes, their ear lobes get warm, which is due to heating of blood by microwave energy of 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 and ear tumor. Also, overuse of cell phones leads to drying of the skin and fluid in the eyes, sleep disorder, lack of concentration, memory loss, and even cancer.

Interphone study report in May 2010 mentioned that excessive users of mobile phones (i.e., half hour/day over 8 to 10 years) have doubled to quadrupled brain tumor risk. They claimed 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 only 2 hours/month, which is only 4 minutes/day. Re-evaluation of the Interphone study by a group of eminent scientist has found that even for average users, increase in brain tumor is significant over greater than 10 years of use. Interphone Study excluded children from the study. Children are at higher risk than adults due to the fact that their skulls are thinner and still developing. On May 31, 2011, International Agency for Research in Cancer (IARC), part of WHO (World Health Organization), designated cell phones as “Possible Human Carcinogen”. They found evidence of increase in glioma and acoustic neuroma brain cancer for excessive cell phone users. Surprising, they have not mentioned about cell tower radiation, which is 24x7.

3. Radiation from cell towers

Cell tower antennas transmit in the frequency range of 869 to 890 MHz (CDMA), 935 to 960 MHz (GSM900), 1810 to 1880 MHz (GSM1800) and 2110 to 2170 MHz (3G). Mobile phone operators divide a region in large number of cells, and each cell is divided into number of sectors. Generally, there are three sectors with equal angular coverage of 120 degrees in the horizontal direction. The base stations are connected to directional antennas that are mounted on the roofs of buildings (RTT – Roof Top Tower or RTP - Roof Top Pole) or on Ground Based Towers (GBT). The antennas may have electrical or mechanical down-tilt, so that the signals are directed towards ground level. Large numbers of these towers are mounted near the schools, hospitals, residential and office buildings to provide good mobile phone coverage to the users. These cell towers transmit radiation 24x7, so people living within 100'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.

Based on the information received from cell phone operators, majority of them, use 2 to 12 carrier frequencies (average may be around 6) and they transmit 20W of power per carrier. For example (arranged in alphabetical order):

Aircel has nearly 1900 towers in Kolkata, and use mostly 8 carriers though it varies from 6 to 12. It has nearly 2700 towers in Rest of Bengal, and number of carriers varies from 6 to 12 but they also have 24 carriers at around 10 places.

Idea has nearly 1550 towers in Kolkata, and uses mostly 6 carriers and upto 12 carriers at a few places. It has nearly 2000 towers in Rest of Bengal, and uses mostly 6 carriers though at some places, number of carriers varies from 3 to 12.

MTS has 460 towers in Kolkata, and uses 2 carriers. It has 830 towers in Rest of Bengal and uses 2 carriers.

Tata Teleservices has 569 CDMA towers having 2 carriers and 1346 GSM towers having mostly 2 to 3 carriers in Kolkata. It has 628 CDMA towers having 1 to 2 carriers and 1407 GSM towers having 2 to 4 carriers.

Uninor has nearly 1000 towers in West Bengal, and uses mostly 6 to 8 carriers, though it varies from 2 to 10.

No information has been received from Vodaphone, Airtel, Reliance, and other operators.

So, one operator may be transmitting nearly 100W of RF power depending upon number of carriers. There may be 2 to 3 operators on the same roof top or tower, thereby total transmitted power may be 200 to 400W. In addition, majority of them, use directional antennas of gain = 18 dB. Assuming 1 dB cable loss, effective gain = 17 dB (numeric value is 50), so effectively, several KW of power may be transmitted in the direction of main beam.

3.1 Radiation pattern of the antenna

The radiation pattern in horizontal and vertical planes of a 3G antenna of 18 dB gain is shown in Figure 1. This pattern is taken from the datasheet of the antenna used by one of the

operators. In the horizontal direction, half-power beam-width (HPBW – defined as angular range over which maximum power decreases to half of its value) is 65 degrees. In the vertical direction, there is one main lobe and several side lobes. For the main lobe, HPBW is 6 degrees. There are several side lobes, whose maximum levels are about -13 to -30 dB below the main level.

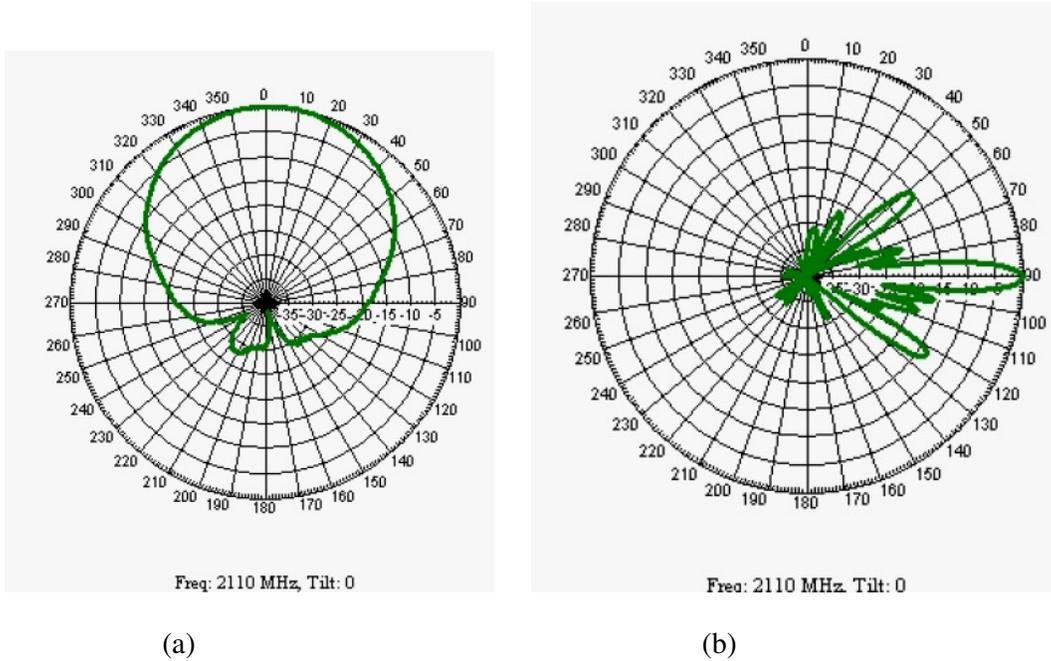


Figure 1 – (a) Horizontal and (b) Vertical radiation pattern of 18 dB gain antenna

3.2 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 $P_t = 20$ W, $G_t = 17$ 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 $\mu W/m^2$
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.

3.3 Theoretical and measured radiated power

To measure the power at a distance R from the transmitting cell tower antenna, antenna and spectrum analyzers are used to measure received power P_r , which can be calculated as:

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

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

At 887 MHz (tower transmitting frequency in CDMA), $P_r = -3.2$ 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

Power density for all these frequencies is $31,800 \mu\text{W}/\text{m}^2$.

Measurements of received power at several locations in Kolkata were taken by IIT Kharagpur professors and their team members using a dipole antenna and Spectrum Analyzer. Measurements of received power at several locations in Kharagpur were taken under the supervision of IIT Bombay and IIT Kharagpur professors and their team members The set-up is shown in Figure 2.

At one of the sites at Kolkata, measurements were done in the presence of West Bengal Environment Minister Dr. Sudarsan Ghosh Dastidar. Pictures of the measurements monitored by him and the cell towers are shown in Figures 3 and 4. Picture of the reading of the spectrum analyzer using a dipole antenna tuned at 900 MHz is shown in Figure 5. A peak of -1.13 dBm at 945 MHz (corresponding to GSM900) is noted along with several other bands.

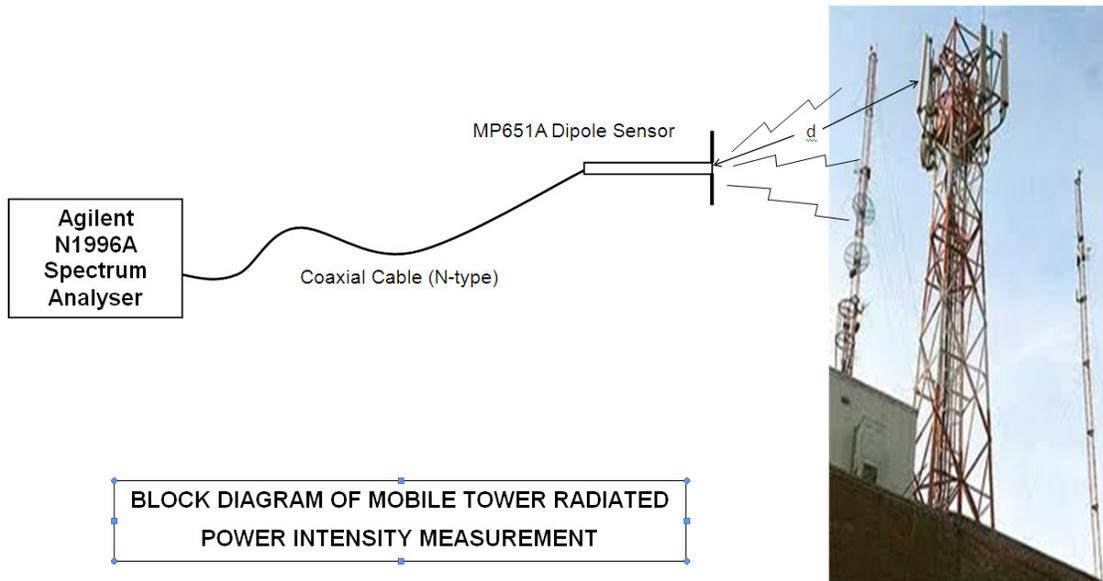


Figure 2 – Measurement of received power using dipole antenna and spectrum analyzer



Figure 3 – Measurement of received power in the presence of WB Environment Minister



Figure 4 – Picture of the cell tower where measurements were carried out in the presence of WB Environment Minister

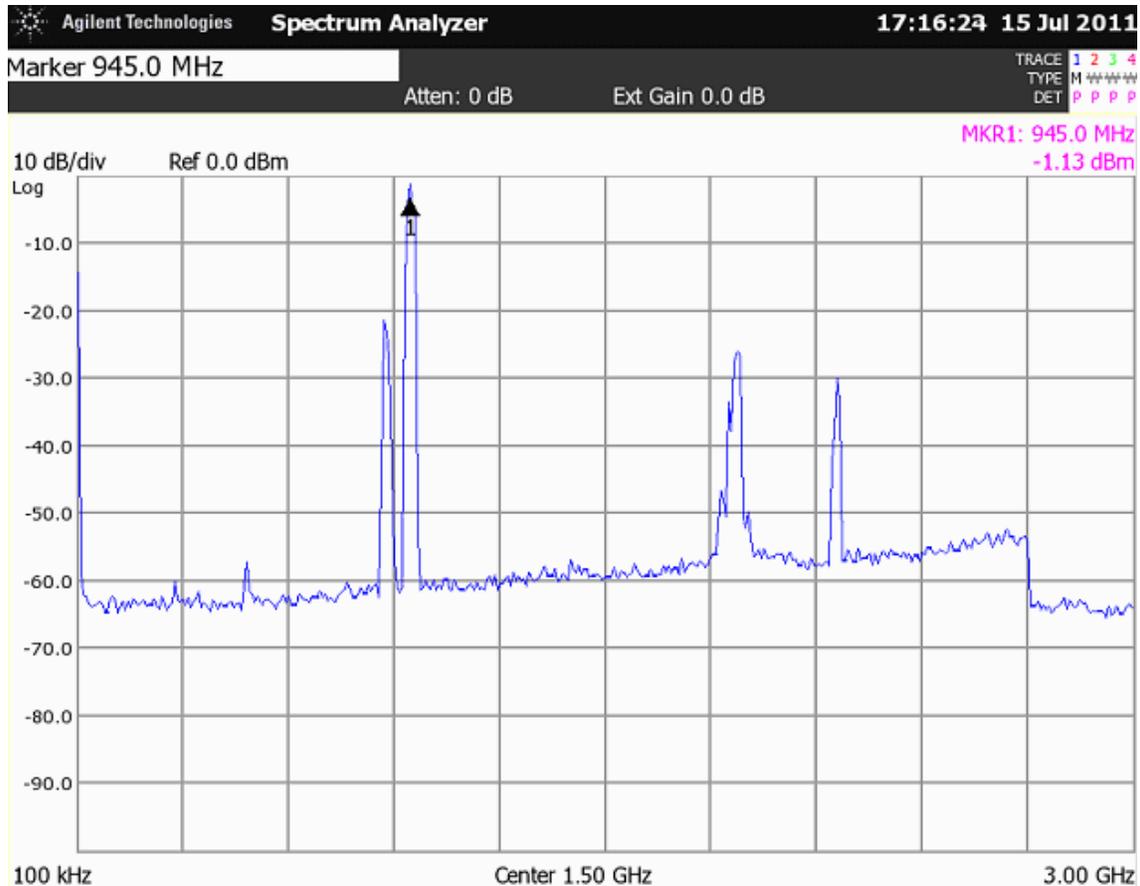


Figure 5 – Measured power using spectrum analyzer showing multiple bands

The measured power levels at various sites for different frequencies are shown in Table 2. Calculated radiation density using calibration charts, after accounting for cable loss at different frequencies, is also shown.

Table 2 – Measured power at various sites and distances from the transmitting tower

Tower No. 1- Top Floor of Dhakuria Sri Ram Roy Institution, Date – 14.07.2011
Height of Tower – 48 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_f) ($\mu\text{W}/\text{m}^2$)
1.	950	25	-28	3.78	159
2.	951	25	-20	3.78	1,005
3.	951	20 (out door)	-22	3.78	634
4.	951	20 (inside room)	-30	3.78	100
5.	951	5 (School Building Top Floor)	-30	3.78	100
6.	876	„	-33	3.58	43
7.	951	8.5 (Ground Floor of School building)	-18.6	3.78	1,387

Tower No. 2 - Back side of R.G. Kar Hospital, Date – 14.07.2011
Height of Tower – 60 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	937.2	45 (N/W of Top Floor)	-7.74	3.75	16,788
2.	937.2	45 (N/E of Top Floor)	-13	3.75	5,000
3.	937.2	50 (S/W of Top Floor)	-20	3.75	998
4.	937.2	50 (S/E of Top Floor)	-33	3.75	50
5.	937.2	45 (North side of 2 nd Floor)	-18.77	3.75	1,324
6.	937.5	45 (North window of 1 st Fl.)	-22.84	3.75	519
7.	1875	„	-28.75	5.94	1,104
8.	937.4	45 (Ground Floor North side)	-44.14	3.75	4
9.	941	10 (Tower Building bottom)	-33	3.75	50
10	941	15 (from tower building bottom)	-25	3.75	315

Tower No. 2 - Back side of R.G. Kar Hospital, Reading taken from Nurse Hostel of R.G. Kar Hospital, Date – 15.07.2011, Height of Tower – 60 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	937.5	30 (East side of Ground Floor)	-17.0	3.75	1991
2.	945	17 (W/N wing of 5 th Floor)	-1.13	3.76	77,090
3.	945	17 (W/N inside balcony of 5th Floor)	-3.95	3.76	40,272
4.	945	16 (Top Floor near water tank)	-1.52	3.76	70,469

Tower No. 3 -Asirbad Apartment, 10 no. Jassore Road

Date – 14.07.2011, Height of Tower – 25 feet from Top Floor

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	937.5	4 (South side of Top Floor)	-8.78	3.75	13,213
2.	885.2	4 (S/E of Top Floor)	-15.97	3.60	2,173
3.	937	3 (N/E of Top Floor)	-7.5	3.75	17,742
4.	937	3 (North side of Top Floor)	-4.85	3.75	32,659

Tower No. 4 - 8/2a Bose para Lane, Date – 15.07.2011, Height of Tower – 50 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	942.5	10	-15.52	3.75	2,799
2.	945	20 (32A, Giris Avenue)	-23.16	3.75	482
3.	915	20	-31.27	3.68	66
4.	885	20	-30.14	3.60	79

Tower No. 5 - SDO Office, Kharagpur, Date – 08.08.2011 Height of Tower – 48 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	938	600	-57.47	3.74	0.2

Tower No. 6 - DRM Office Building, Kharagpur,

Date – 08.08.2011, Height of Tower – 40 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Intensity (W_r) ($\mu\text{W}/\text{m}^2$)
1.	938	15 (inside Senior DEN Office)	-17.81	3.74	1,648
2.	882	12 (outside office)	-27.62	3.43	578

Tower No. 7 - M.M. Building, Puratan Bazar, Kharagpur,
Date – 08.08.2011, Height of Tower – 40 feet

Sl. No	Frequency (f) (MHz)	Distance (R) (m)	Power Level (P_r) at SA (dBm)	Cable loss (L) (dB)	Radiation Density (W_r) ($\mu\text{W}/\text{m}^2$)
1.	877	10 (2 nd Floor)	-16.1	3.58	2,004

Measured power levels after accounting for cable losses at several places varies between 0 to -10 dBm, which is extremely high. The purpose of a cell tower is to enable cell phone to 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 several places is at least 50 to 80 dB higher, which translates to 100,000 to 100,000,000 times stronger signal than a mobile phone requires. There are millions of people who live near these cell towers and absorbing this radiation 24x7.

The measured received power values are comparable to the theoretical values in the direction of main beam. Measured values are much lesser than the theoretical values in the directions other than main beam of radiation because of reduction in the gain in that direction. Hence, it is important to know the radiation pattern of the antenna to know the exact radiation density at a given location. The calculated radiation densities in Table 2 are for a single carrier. For multiple carriers, cumulative radiation level will be much higher.

However, all the above readings of radiation density are within the ICNIRP guidelines of safe radiation, which are adopted in India. Yet, many people living closer to these towers have several health problems.

4. Radiation norms adopted in India and other 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 $4.7\text{W}/\text{m}^2$ and for GSM1800 transmitting band (1810-1880 MHz), it is $9.2\text{W}/\text{m}^2$. However, ICNIRP guidelines clearly state that these are only for short term exposure (averaged over 6 minutes of time) and not for long term exposure. A limit, which is only for short term exposure, how that limit can be applied for 24x7?

Bio-Initiative Report in 2007 (610 pages long) was prepared by a group of scientists after thorough survey of the scientific literature and they concluded that the existing standards for public safety are inadequate to protect public health. They proposed safe limit of $1000 \mu\text{W}/\text{m}^2$ for outdoor, cumulative RF exposure and $100 \mu\text{W}/\text{m}^2$ for indoor, cumulative RF exposure.

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

- a. $<0.1 \mu\text{W}/\text{m}^2$ - no concern
- b. $0.1 - 10 \mu\text{W}/\text{m}^2$ - slight concern
- c. $10 - 1000 \mu\text{W}/\text{m}^2$ - severe concern
- d. $> 1000 \mu\text{W}/\text{m}^2$ - extreme concern

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

Current USA standard for radiation exposure from cell phone towers is 580-1,000 microwatts per sq. cm. ($\mu\text{W}/\text{cm}^2$), which is equivalent to 5.8-10 W/cm^2 , but they are now considering revising the norms. However, implementations of these norms are very strict. According to FCC Guidelines – Human exposure to RF fields, Cellular cell site towers are typically 50-200 feet high. Majority of cellular or PCS cell sites in urban and suburban areas operate at an ERP of 100 watts per channel or less. An ERP of 100 watts corresponds to an actual radiated power of 5-10 watts, depending on the type of antenna used. In urban areas, cell sites commonly emit an ERP of 10 watts per channel or less.

<http://www.fcc.gov/guides/human-exposure-rf-fields-guidelines-cellular-and-pcs-sites>

In INDIA, cell sites transmit 100's of Watts of power with antenna gain of 50, so ERP = 5000 Watts.

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 1000 to 100,000 $\mu\text{W}/\text{m}^2$ (1/100th to 1/1000th of ICNIRP guidelines) as can be seen at:

http://www.buildingbiology.ca/input/wp-content/uploads/2011/08/2011_July_Cell_Tower_Radiation_Guidelines.pdf

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 = 3m 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 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 W/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 m and waist 34" = 86 cm). So, power received by human body will be power density x area = 6.75 Watts. In one hour, microwave energy absorbed will be 6.75 x 3600 = 24.3 KW-sec. In one day, microwave energy absorbed will be 24.3 x 24 = 583.2 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 KW-sec / 500 W = 1166 seconds = 19 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? Also, this value is only for a single source. For multiple sources, it will increase correspondingly.

A number of adverse health effects have been documented at levels below the FCC and ICNIRP 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 6 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.

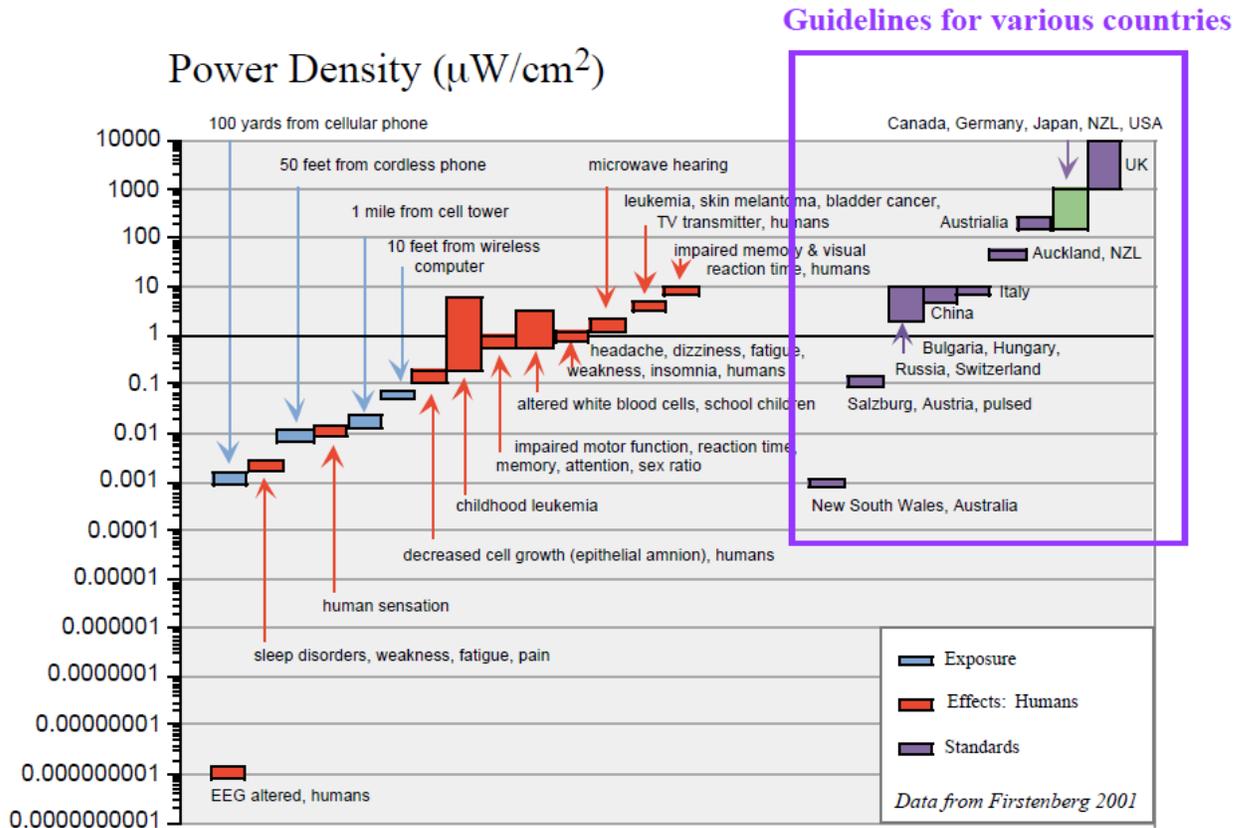


Figure 6 - Guidelines, exposures and effects of radio frequency radiation at various power densities. Data from Firstenberg 2001.

It may be noted that sleep disorder, weakness, fatigue and pain occur at radiation density level of $0.003 \mu\text{W}/\text{cm}^2 = 30 \mu\text{W}/\text{m}^2$, human sensation starts at $0.01 \mu\text{W}/\text{cm}^2 = 100 \mu\text{W}/\text{m}^2$ and severe health problems occur at $1 \mu\text{W}/\text{cm}^2 = 10,000 \mu\text{W}/\text{m}^2$, such as, childhood leukemia, headaches, dizziness, insomnia, impaired motor function, and so on. Based on severe health effects, many countries adopted much lower safer guidelines. For example, safe radiation density limit for various countries are: New South Wales, Australia: $0.001 \mu\text{W}/\text{cm}^2 = 10 \mu\text{W}/\text{m}^2$, Salzburg, Austria: $0.1 \mu\text{W}/\text{cm}^2 = 1000 \mu\text{W}/\text{m}^2$, Russia, China, Switzerland, Italy: less than $10 \mu\text{W}/\text{cm}^2 = 100,000 \mu\text{W}/\text{m}^2$, UK, USA, India: around $1000 \mu\text{W}/\text{cm}^2 = 10,000,000 \mu\text{W}/\text{m}^2$. The above standards were adopted in 2001, and now many countries have started adopting lower safe radiation level. Also, protest by people from various countries is going on to reduce the radiation level. A search of “Cell tower radiation” on www.google.com will give nearly million of sites and technical search can be done by using above search words at www.scribd.com/doc/44736879/Cell-Tower-Radiation-Report-sent-to-DOT-Department-of-Telecommunications.

A very comprehensive report has been prepared by Prof. Girish Kumar, Electrical Engineering Department, IIT Bombay and submitted to Secretary, DOT in Dec. 2010. It consists of 30 pages of report with more than 200 scientific and technical references. <http://www.scribd.com/doc/44736879/Cell-Tower-Radiation-Report-sent-to-DOT-Department-of-Telecommunications>

5. Inter-Ministerial Committee (IMC) Report

The safe limit adopted by India is extremely high and large population has been suffering because of this and there have been complains from various parts of the country. Hence, Inter-ministerial committee (IMC) was formed in 2010 consisting of officers from Department of Telecom (DOT), Indian Council of Medical Research (ICMR), Ministry of Health, Department of Biotechnology and Ministry of Environment and Forest. IMC report was uploaded on DOT website (attached as an appendix) in Jan. 2011. In IMC report, they have given scientific evidence and research of several health effects due to cell tower radiation and epidemiology studies reported in various countries (pages 18-27). They have even mentioned EMF exposure limits from mobile base stations in various countries (pages 28-33) and recommendations of Bio-initiative report of safe limit of $1000 \mu\text{W}/\text{m}^2$ for outdoor, cumulative RF exposure and $100 \mu\text{W}/\text{m}^2$ for indoor, cumulative RF exposure. Yet on Page 44, they have recommended that RF exposure limits in India may be lowered to $1/10^{\text{th}}$ of the existing level, which will be for GSM1800, whopping $920,000 \mu\text{W}/\text{m}^2$.

6. Biological effects of cell phone and cell tower 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 are 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. Children are more vulnerable to cell phone/tower radiation as their immune system is not as well developed as adults and will have longer life time exposure. 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 exposure to cell phone and tower radiation.

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. 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.

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. Microwave radiation can also interfere with the natural processes involved in DNA replication and repair. 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. 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.

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.

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). 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.

Radiation from cell towers and mobile phones affects human skin. The radiation degrades 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, etc.

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. 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. 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 and ear tumour.

Frequent use of mobile phones can also damage the visual system in many ways and cause uveal melanoma i.e. tumor of the eye. 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. Prolonged exposure to microwave radiation 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.

Various studies show that exposure to EMR reduce melatonin levels in animals and humans. 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. 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.

Electromagnetic fields have been shown to affect the brain physiology. Use of the cell phones 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 percentage increase in sleep disturbance is proportional to the exposure dose. It has been reported that even at radiation density of $10 \mu\text{W}/\text{m}^2$, disturbance in the sleep is of the order of 35%. When the transmitter was turned off, the symptoms resumed gradually

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.

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 and acoustic neuroma. 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 in May 2010 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. This is later substantiated by International Agency for Research in Cancer (IARC), part of WHO (World Health Organization) in May 2011.

7. 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.

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 300m 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)

This study 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. Cancers of the prostate, pancreas, bowel, skin melanoma, lung and blood cancer were all increased.

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 1,100 to 1,900 $\mu\text{W}/\text{m}^2$, which is considerably lower than ICNIRP guidelines of 4,700,000 $\mu\text{W}/\text{m}^2$. This demonstrates that present guidelines do 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 electro-hypersensitive (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.

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:

Usha Kiran Building in Mumbai has reported 6 cancer cases in sequential floors as they were in the main beam of the transmitting tower antenna in the opposite building. In Andheri, 15 cancer cases have been reported due to heavy cluster of cell towers. 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:

Within 91 m from a mobile tower			
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

Example 7: Brazil

It is reported in May 2011 that electromagnetic radiation emitted by transmitting cell phone antennas is linked to the occurrence of some types of cancer. Out of 4,924 cancer patients, nearly 80% of them lived within 500m from one of the radiating towers.

http://www.next-up.org/pdf/Brazil_New_study_direct_link_to_4924_cancer_deaths_from_cellular_antennas_radiation_28_07_2011.pdf

8. 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 (power = power density x 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.

In several countries, an abrupt disappearance of bees has been 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 background noise that seems to disrupt intercellular communication within individual bees. 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. The current dying/vanishing of honey bees can have serious consequences for human health.

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. During recent decades there has been a marked decline of the house sparrow population. A house sparrow is 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.

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. 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.

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/tower radiation can choke seeds, inhibit germination and root growth, thereby affecting the overall growth of agricultural crops and plants. Trees located inside the main lobe (beam), have much lower fruit yield, have dried tops, show slow growth and high

susceptibility to illnesses and plagues. Also, electromagnetic radiation generates heat, which may kill micro-organisms present in the soil near it. This in turn harms those organisms which feed on them and disturbs the ecological cycle.

9. 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 radiation density level of $0.001 \text{ W/m}^2 = 1000 \mu\text{W/m}^2$. Some 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 0.01 W/m^2 , which should then be subsequently reduced to 0.001 W/m^2 within 1 to 2 years, so that network planning can be carried out in a phased manner. All the operators must be strictly instructed to reduce the transmitted power to 1 to 2W in the urban area. The 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 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; which will reduce the noise and air pollution. Reduction in carbon emission will earn 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 0.1W 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 24x7, 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 by Rs. 0.10 per minute, 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.

10. 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 1/100th to 1/1000th 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.

11. Recommendations

1. The amount of studies and investigations on the subject of cell tower radiation has assumed a critical proportion to alert the users and the regulators about the harmful nature of its effects. This has a close parallel to the incidence of cigarette industry and “Green House Gas” effects on the warming of the planet. There was considerably delayed action by the authorities/regulators, thus making irreversible ill-effects for human and our planet. The point here is to take lessons from our early experience and get prepared to take some concrete steps on curbing the damaging effects of mobile tower radiation before it is too late.
2. The current guidelines adopted in India are 1998 WHO approved ICNIRP norms, which allows 4.7 Watt/sq.m (940 MHz) to 9.2 watt/sq.m (1840 MHz). However, many countries of the world, both developing and developed, have adopted much stricter guidelines. It is pertinent to note here that in China, the corresponding guideline is 0.1 Watt/sq.m.
3. The committee has extensively studied the scientific literature, journal communications, etc. published all over the world. Also the committee has mapped the actual electromagnetic radiation data in various locations of cell phone towers in Kolkata and outside using spectrum analyzer. The evidence is overwhelming to the extent of pointing an impending danger of the cumulative effects of such electromagnetic radiation emanating from the cell phone towers and alike.
4. Many national and international bodies suspect that there could be some effects from microwave transmission even at very low power level. Therefore, as the concerned authorities all over the worlds take a cautious approach, the committee feels to take precautionary measures without hindering the growth of the mobile communication at the same time keeping the general population not exposed to higher power levels from the mobile tower transmissions. Based on our studies, we strongly agree with the recommendations made in Bio-initiative report, i.e. safe limit for maximum radiation density of $1000 \mu\text{W}/\text{m}^2$ for outdoor, cumulative RF exposure and $100 \mu\text{W}/\text{m}^2$ for indoor, cumulative RF exposure.
5. It is recommended that maximum cumulative power density allowed should be reduced with immediate effect to $0.01 \text{ W}/\text{m}^2$, which should then be subsequently reduced to $0.001 \text{ W}/\text{m}^2$ within 1 to 2 years.
6. Currently, operators are pumping out 100’s of Watts of RF power in the atmosphere, they are not only ruining the health of the people but they are ruining the environment – birds, animala, trees, fruit yield, crops, etc. It must be declared as crime against humanity and community, and much more reprehensible than individual killing.
7. Transmitted power from each cell tower must be immediately reduced to maximum 1 to 2W, which will protect health of the people from harmful effects of cell tower radiation. It will also protect birds, animals, plants, trees and environment.
8. The reduced transmitted power may create signal problem to the people living near the edge of the circle in the beginning, so public announcement must be made that this is being done to protect the health of the people. People must be educated about adverse health effects of cell phone and cell tower radiations.

9. Towers both ground based and roof based should not be installed within 50 meters from schools or hospitals. New towers should be located 50 meters away from school and hospital buildings. Existing towers should be relocated within a year if they are located within 50 meters from the schools or hospital buildings.
10. Installation towers in the residential areas will be allowed only in consultation with the concerned resident welfare association and not left to bilateral negotiations between telecom companies and individual residents.
11. Installation of base station antennas in lanes narrower than 7 meters should be avoided in order to reduce the risk caused by earth quake and wind related disasters.
12. Antennas should be mounted on or above 30 meters from the ground where the power of transmitting antenna is 10 watts or above. Micro and Pico cell antennas mounted inside the building should not exceed 0.1 watt.
13. Utmost care must be taken to ensure that main beam of the antenna is not in the direction of residential/office buildings as well as, where there is large concentration of people, animals, birds, trees, etc. Operators must be infomed, **“Reduce the Power or Remove the Tower”**
14. 24 hours monitoring of cell tower radiation must be done at various places. Radiation from cell tower varies considerably over a day, and it is generally maximum during the peak hours and minimum during the night.
15. Once power transmitted is reduced, power amplifiers may not be required at most of the places and no cooling will be required. This will reduce the electricity consumption substantially, which can be easily managed by renewable energy sources.
16. Once power requirement is reduced, Diesel Generators (DG) will not be required in most of the places. This will reduce air and noise pollution.
17. The above measures will reduce carbon footprint thereby generating carbon credits.
18. Hotline or email-id or websites must be created, where people can call or write their health problems associated with cell phone/tower radiation.
19. Epidemiology studies must be initiated in various parts of the country.
20. Warning sign boards must be installed near cell towers to warn people of the danger of radiation.

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Appendix A – Calculation of Radiation Intensity from Spectrum Analyser

Let the received power shown by Spectrum Analyser at frequency f be P_r dBm.
(Actually Spectrum Analyser displays Power contained in a resolution bandwidth).
Incorporating cable loss L (dB), the power received at the cable end of the sensor is

$$P_{rin} (dBm) = P_r + L$$

$$\text{So, } P_{rin} = 10^{\frac{P_{rin} (dBm)}{10}} \text{ mW} = 10^{\frac{P_{rin}}{10}} \times 10^{-3} \text{ W}$$

Now, assuming that cable is matched to Spectrum Analyser and the impedance level of Spectrum Analyser plus cable to be 50Ω .

The equivalent wave voltage at the cable end of sensor is

$$\begin{aligned} V &= \sqrt{P_{rin} (Watts) \times 50} \text{ Volts} \\ &= 20 \log_{10} \sqrt{P_{rin} (Watts) \times 50} \text{ dBV} \\ &= 120 + 20 \log_{10} \sqrt{P_{rin} (Watts) \times 50} \text{ dB}\mu\text{V} \end{aligned}$$

From the antenna factor chart of MP651A Dipole sensor (provided by the manufacturer M/S ANRITSU Corporation, Japan and attached herewith) at the measuring electromagnetic wave frequency, the conversion factor from Voltage (in $\text{dB}\mu\text{V}$) to Electric field is obtained as $K(\text{dB})$.

So, received electric field magnitude at the sensor plane is

$$|E_{rd}| = V(\text{dB}\mu\text{V}) - K(\text{dB}) - 120(\text{dB V/m})$$

So, the received electric field magnitude at the sensor plane is

$$E_r = 10^{\frac{E_{rd}}{20}} \text{ V/m}$$

Assuming plane wave incidence on the E-field sensor, the radiation intensity is calculated as,

$$\text{Radiation Intensity, } W_i = \frac{|E(\text{V/m})|^2}{\eta_0} \text{ (W/m}^2\text{)}$$

where $\eta_0 = 377\Omega$ is intrinsic impedance of free space.

Appendix B -

"Study on Adverse Biological and Medical Effects of Radiation on Human Beings due to Mobile Phones."

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Introduction:

The effect of radiation in human beings have been studied for a long time. There has been various clinical, epidemiological studies on the hazards of RF radiation. These researches date back to 1950's and researches are being done on this topic still now. There has been different phases of research presenting some conclusive view at the end of each phase. New advances in field of RF and Microwave field as well as in the medical field have been changing the track of the RF Hazard related research. Therefore this research is very dynamic and it's very difficult to settle to a final conclusion. And an important feature of this research is controversies among the researchers regarding the effect. In the field of RF mobile phones is such an advancement which has resulted into some drastic change in this research work. Throughout the years there has been various standards developed by eminent bodies to ensure the public interest against the threats of RF radiation. In order to get a total view on this topic we try to analyse different phases of research from 1950's to till date.

Research Influenced by Mobile Phone:

In 1953 McLaughlin reported on the possibility of Leukaemia as an effect of radiation. In 1979, Wertheimer and Leeper[26] published results of their residential study indicating increased incidence of leukemias and some other neoplasms in children whose houses had exposure to above normal intensities of power frequency magnetic fields. One important of such a study has been by Stanislaw Szmigielski [25]. It was based on data on Cancer morbidity in Poland, (1971-1985), aimed at determining the relation between exposure to occupational hazards, apart from the list of carcinogens already listed by WHO, IARC etc., and promotion of neoplastic transformations and spread of Tumours. Among such hazards, exposure to EM radiation was an important one. Subjects exposed to microwave radiation occupationally were put under the study based on the age group to which they belong and their type of malignancy. Studies by Dennis in UK, have also suggested similar results. Biological effects that result from heating of tissue by RF energy are often referred to as "thermal" effects. It has been known for many years that exposure to high levels of RF radiation can be harmful due to the ability of RF energy to heat biological tissue rapidly. This is the principle by which microwave ovens cook food, and exposure to very high RF power densities, i.e., on the order of 100 mW/cm^2 or more, can clearly result in heating of biological tissue and an increase in body temperature. Exposure to RF energy at power density levels of $1\text{-}10 \text{ mW/cm}^2$ and above can result in measurable heating of biological tissue (but not necessarily tissue damage). The eyes and the testes, are known to be particularly vulnerable to heating by RF energy because of the relative lack of available blood flow to dissipate the excessive heat load (blood circulation is one of the body's major mechanisms for coping with excessive heat). Laboratory experiments have shown that short-term exposure (e.g., 30 minutes to one hour) to very high levels of RF radiation ($100\text{-}200 \text{ mW/cm}^2$) can cause

cataracts in rabbits. Temporary sterility, caused by such effects as changes in sperm count and in sperm motility, is possible after exposure to high-level RF radiation. The difference between number of victims of cancer, exposed or not exposed to radiation was not very high. Influence of other carcinogens in their activities could not be properly compared. So results were not that convincing. But the thermal effects of radiation were taken to be a fact which reflects in different standard setting at that time. The research, standard setting, and other RFR (Radio Frequency Radiation) related activities described above have been undertaken by Tri-Services of the U.S. Department of Defence to identify and manage potential hazards of exposure to RFR. [SI]. During the period 1993-1997, the TERP (Tri-Services Electromagnetic Radiation Panel) took the leadership in revising the NATO Standardization Agreement (STANAG) “*Control and Evaluation of Personnel Exposure to Radio Frequency Fields -3 kHz to 300 GHz*”. This agreement, STANAG 2345, is based on both the IEEE standard and DODI (Department of Defense INSTRUCTION). During this process, TERP personnel strongly supported the publication of the most complete work on RFR standard setting, thereby allowing maximal utilization of electromagnetic energy with minimal hazard to personnel and the environment.

The FCC(Federal Communications Commission) considered comments submitted by the EPA(Environmental Protection Agency), FDA(Food and Drug Administration), NIOSH (National Institute Of Occupational Safety & Health) and OSHA(Occupational Safety and Health Administration), which have primary responsibility for health and safety in the Federal Government. The guidelines the FCC adopted were based on the recommendations of those agencies, and they have sent letters to the FCC supporting its decision and endorsing the FCC’s guidelines as protective of public health. The research in the field of RF Hazards was not influenced by the mobile phone related radiation in this era, though the usage of mobile phone was starting to increase from this period only. In the mid of nineties there had been some effort to do research on the effects of mobile phones, but these efforts were only short term based as there was no scope for long term research over that new technology.

Research prior to Digital Cellular Phones:

Though the mobile communication dates back to 1980's, it's in the 1990's that there has been an explosion in the number of cell phone usage. And therefore it's around advent of this century that there were three prominent generation using cell phone. And at one generation has been using the mobile phone for more than a decade. So there was a good opportunity for the research of long term effect of radiation due to mobile phones and towers, and many research or studies were undertaken by many eminent international institutions.

The INTERPHONE project, coordinated by the International Agency for Research on Cancer (IARC), which was launched at the late 90's began to appear in 2004 and 2005. We can conclude from the various reports published under this study that for regular mobile phone users there is no risk of cancer though there is in some cases elevated risk levels in the case of over 10 years usage of mobile phone. [19]

The Health Evidence Network (HEN), under WHO Europe, published report [20] on health hazards of RF radiation from mobile phones. This report suggests that results in various studies, e.g. epidemiological, in vitro, cannot suggest direct relation to health hazards and mobile phone usage. But long term (more than 10years) use of mobile in a few reports show some statistical between mobile usage and brain tumours. But the results are not convincing and many other reports state otherwise. But in the case of acoustic neuroma - a rare benign tumour of the auditory nerve-though the reports suggest a positive relation

between long term mobile usages.

In 'Independent Expert Group on Mobile Phones'[21] popularly known as 'Stewart Report' there is the indication that the exposure within the international ranges suggested may cause some health problems. "We conclude therefore that it is not possible at present to say that exposure to RF radiation, even at levels below national guidelines, is totally without potential adverse health effects". And in this report various precautionary measures were suggested.

Together, the findings of Preece et al (1999) and Koivisto et al (2000) from human laboratory studies of the acute effects of exposure to mobile phone signals suggest that exposure to mobile phone signals at exposure levels that fall within existing exposure guidelines have biological effects that are of sufficient magnitude to influence behaviour. The causal mechanism is unclear, but could include a small, localised heating effect.

During this period there had been various changes in the mobile technology. One of the important changes is the substitution of analog systems with digital systems in mobile technology. The use of digital technology had significantly brought down the power level for mobile communication. There had been introduction of new modulating methods. Thus this period, though deal with the widespread epidemiological studies on long term exposures to radiation from mobile phones, can not conclusively predict the outcome of the newly implemented technologies in the coming years. There is another important change that had taken place in this period that many teenagers as well as children had started using cell phones, compared to the previous decades where the usage had been restricted amongst the adults. This had created a scientific problem that the effect of radiation on these age groups was unknown and precautions must be taken. **Research after Digital Cellular Phones:** In a whole, until 2005 – 2006, international standards have focused on the thermal effects alone ignoring the long term effects for their inconsistency. But in some contemporary studies and in recent studies some negative effects of cell phone radiation have definitely been noticed.

A)Electromagnetic Radiation effects from cell phone mobile terminal :

Association between cell phone radiation and cell changes including damage to chromosomes, changes in the normal activities of some genes and an increased rate of cell division are detected in [1], [2], [3]. In 2007 informed [12] informed that there are experimental evidences that weak electromagnetic fields can remove calcium ions from the cell membranes. [13] Informs that there is no increased risk of cancer in the long term users except the acoustic neuroma in which there is an indication of association. Another study by Christensen et al., [4], indicates that long-term cell phone use increases the risk of brain tumours. In August 2007, an international working group of scientists, researchers, and public health policy professionals (the BioInitiative Working Group) released its report on EMF and health. It raised evidence-based concerns about the safety of existing public limits that regulate how much EMF is allowable from power lines, cellular phones, base stations, and many other sources of EMF exposure in daily life. But the Committee on Man and Radiation (COMAR) conducted a study in the year 2009 which reported that the effects on health posed by RF does not support the safety limits recommended by the BioInitiative group. COMAR recommended the government authorities and public health officials to continue with the standards provided by IEEE/ICES and ICNIRP. James.C.Lin of the University of Illinois-Chicago informed in 2009 cell phone usage of 10 years or more showed an increased odds ratio of 1.39 i.e. 39 % increased risk of gliomas in the ipsilateral side of brain. The INTERPHONE study indicated an association between cell-phone use and parotid gland

tumours [6]. The September 23, 2008, issue of NCI Cancer Bulletin included the following quote: “We now have studies covering up to 10 years of cell phone usage, and we’re still not seeing any convincing evidence of an increased risk,” In 2008 a report by Charles Graham, PhD, Physiologist at the Midwest Research Institute in Kansas City said that electromagnetic radiation affects hormone levels. When women were exposed to EMR estrogens level increased which increases the risk for cancer. Also the level of testosterone in men decreases due to EMR which is linked to prostate and testicular cancers. [6] Doctors reported that men, using cell phone more than 4 hours a day had a sperm count 25% less than the sperm count of men who never used a cell phone. 50% decrease in the number of properly formed sperms was noted. Sperm count, motility, viability and appearance all were significantly affected. They advised men and women not to carry a cell phone on a belt clip or in a pocket close to the body. Neither any one should work with a laptop on his/her lap. A study [7] by neurologist Dr. Leif Salford informed that toxins and harmful proteins can pass out of the blood into the brain while the cell phone is switched on. The U.S. Dept. of Energy found that cell phone usage while driving will severely damage memory and reaction time. In addition to the stress of continual mental interruption cell phones can cause a physical stress response in the body. In one study pregnant women were reported to have 180 % increased risk for miscarriage when exposed to intermittent EMR as low as 16 milligauss [8]. A German report, published in The Lancet reported blood pressure elevation in a set of volunteers when cell phones were randomly turned on and off without the participants’ knowledge. Robert Kane, PhD., former Motorola Senior Research Scientist and Technical Staff Member, said this, *“Recent research has demonstrated that even short-term exposure to radiation power densities emanating from a nearby cellular telephone is sufficient to modify brainwave patterns, affect short-term memory, and modify an individual’s ability to perform physical tasks such as driving an automobile.”* He also said, *“The body of available research indicates that operation of a nearby portable cellular telephone will expose a non-user to radiation, some of which will be deposited into the brain of the non-user at levels higher than necessary to elicit undesirable biological effects even though the phone may be more than ten feet away from the non-user.”*

B)Electromagnetic Radiation effects from cell phone mobile towers : Gerd, Enrique, Manuel, Ceferino and Claudio conducted a Spanish study called “The Microwave Syndrome” and found harmful health effects from those living near two cell phone base stations. Fatigue, a tendency to depression, sleeping disorders, difficulty in concentration and cardiovascular problems was the reported health effects. An Austrian Study released in May, 2005, informed that radiation from a cell phone tower at a distance of 80 meters causes significant changes of the electrical currents in the brains of test subjects. All test subjects indicated they felt unwell while radiated and some reported being seriously ill. According to the scientists doing the study, this is the first worldwide proof of significant changes of the electrical currents in the brain, as measured by EEG, by a cell phone base station at a distance of 80 meters. Subjects informed symptoms such as buzzing in the head, tinnitus, palpitations of the heart, lightheadedness, anxiety, shortness of breath, nervousness, agitation, headache, heat sensation and depression. Two-time Nobel Prize nominee, Dr. Gerald Hyland, a physicist, said this about cell phone towers. *“Existing safety guidelines for cell phone towers are completely inadequate. Quite justifiably, the public remains sceptical of attempts by government and industry to reassure them that all is well, particularly given the unethical way in which they often operate symbiotically so as to promote their own vested interests.”* Another study conducted on inhabitants living near or under a cell phone base station antenna produced the following prevalence of complaints: headache (23.5%), memory changes (28.2%), dizziness (18.8%), and tremors (9.4%), symptoms of depression (21.7%), and sleep

disturbances (23.5%) [9]. National Radiological Protection Board (NRPB) issued a report in May of 2000 saying that cell phone does affect the children more than the adults. Karolinska Institute in Stockholm found in a study that that children, exposed to a very low field of 1 milligauss over long period of time have twice the normal risk of leukaemia [10]. [11] concluded that neurobehavioral and cancer probabilities are more in the people living within 500 meters from base stations which is supports by 80 % of the available studies. But there is a chance that the findings of the problems posed by the base stations may be due to the methodological weaknesses. A summary, from [11], of the works related to the health effects of base station radiation is provided below –

TABLE 1 Summary of Epidemiological Studies of Mobile Phone Base Station Health Effects

Publication (Year; Country)	Clinical Assessment	Study Design	Base Station Details	Participants	EMF Measured	Key Findings	Strengths	Limitations
Navarro ² (2003; Spain)	Neuro-behavioral	Survey-questionnaire	GSM-DCS 1800 MHz	101	Yes	More symptoms with closer proximity to base station (< 150 m)	Detailed questionnaire, EMF measured, distances studied ^a	Low participation, self-estimated distances, subjects aware ^b
Santlini ² (2003; France)	Neuro-behavioral	Survey-questionnaire	n/s	530	No	More symptoms with closer proximity to base station (< 300 m)	Detailed questionnaire, distances & other EMF exposures assessed	As above, plus no EMF measurements, no base station details
Eger ² (2004; Germany)	Cancer Incidence	Retrospective case review	GSM 935 MHz	967	No	3 x risk of cancer after 5 yrs of exposure (< 400 m); early age of cancer diagnosis	Maximum beam intensity calculated, reliable cancer data collection	Other environmental risk factors not assessed; analysis not adjusted for age and sex.
Wolf & Wolf ⁸ (2004; Israel)	Cancer Incidence	Retrospective case review	TDMA 850 MHz	1844	Yes	> 4 x risk of cancer after 3-7 yrs exposure (< 350 m); early age of cancer diagnosis	Reliable cancer & demographic data, no other major environmental pollutant identified	Not all environmental risk factors assessed; possible selection bias; no age, sex adjustment.
Gadzicka ⁴ (2006; Poland)	Neuro-behavioral	Survey-questionnaire	n/s	500	No	More headache with proximity < 150 m; nocebo unlikely ^c	Detailed questionnaire, distances & EMF studied, nocebo studied	Subjects aware, no base station details
Hutter ⁵ (2006; Austria)	Neuro-behavioral	Cross-sectional	900 MHz	336	Yes	Headaches & impaired concentration at higher power density; nocebo unlikely	Detailed questionnaire and testing, EMF measured, distances studied; nocebo effect studied	Subjects aware, low participation rate
Meyer ⁹ (2006; Germany)	Cancer Incidence	Retrospective case review	n/s	177,428	No	No increased cancer incidence in municipalities with or without base stations	Wide population assessed (Bavaria)	Observation period only 2 years, vague definitions of exposure, exposure onset unknown, distance to base station unknown
Abdel-Rassoul ⁶ (2007; Egypt)	Neuro-behavioral	Cross-sectional	n/s	165	Yes	More symptoms & lower cognitive performance if living under or < 10 m from base station	Detailed questionnaire and testing, EMF measured, distances studied, subjects unaware	Exact base station details n/s, low number of participants
Blethner ¹⁰ (2009; Germany)	Neuro-behavioral	Cross-sectional	n/s	30,047	No	More health complaints closer to base station (< 500 m)	Wide population assessed, detailed survey, nocebo effect assessed	EMF measurements not carried out (see phase II in Berg-Beckhoff et al., 2009; below)
Berg-Beckhoff ¹¹ (2009; Germany)	Neuro-behavioral	Cross-sectional	GSM 900 MHz GSM 1800 MHz UMTS 1920-1980 MHz	1326	Yes	Health effects probably caused by stress and not by RF-EMF	Measured EMF emissions, standardized questionnaires	Low participation, no detailed list of symptoms published, single "spot" measurement in one place in dwelling, no occupational exposure assessed, time lag from assessment of symptoms and EMF measurement

n / s = not specified.

^a"Distance" refers to distance between base station and subjects' households.

^b"Subjects aware" refers to study participants being aware of the nature of the study.

^c"Nocebo" effect unlikely because the majority of subjects in the study reported little or no concern for base station proximity.

Changes in International Standards over Time:

In the IEEE C95.1-1991[14] the standards were developed using the available literature at that time. In this new version of standard the MPE in the ANSI C95.1-1982[15] was supported citing that there were no scientific reports or evidence to suggest that the previous MPE and the safety factors employed in the 1982 standard was inadequate. But the main biological adversities of radiation considered were the thermal effect of radiation. This was the case, as previously mentioned, in the 90's due to contradictory nature and statistically insignificant results of research related to long term effects of radiation. Throughout the years there were small amendments of the IEEE C95.1-1991 standard, e.g. IEEE C95.1a1999[16], IEEE C95.1b-2004[17]. There were no basic changes in the guidelines of the various limits in these amendments.

Then the revised standard got published as IEEE C95.1TM-2005[18]. In this revised version of standard the non cancer effects(short term effects) have been analyzed properly in section B.2.2 and it has been shown that most of the studies suggest that within the exposure limit ~4W/kg there is none scientifically proven adverse effect. But there has been a mention of some results showing some effects of radiation in lower exposure levels as well. *'Thermal physiology and associated behavioural responses form the basis of the RF*

standard' is the main basis of the whole standard. In the section B.2.3 the cancer related studies have been referred. In this section in the basis of inconsistencies various epidemiological studies have been considered unreliable. Though they have ignored this angle of research they have mentioned that, "While the available results do not indicate a strong causal association, they cannot establish the absence of a hazard".

Besides the IEEE C95.1TM-2005 standard ,by IEEE International Committee on Electromagnetic Safety (SCC39) there are other standards developed by other boards such as National Radiological Protection Board(NRPB), International Commission on Non-ionizing Radiation protection(ICNIRP).The IEEE C95.1TM-2005 standard claimed that it was harmonized with the other international standards (mentioned above).Though the MPE's and BR's suggested similarity there was some basic difference in averaging time and so on.

Conclusions:-

The early studies about the adverse health effects of the cell phone radiation indicate that the harmful effects of radiation was not very convincing. Though some of the articles reported that there is some positive correlation between different symptoms like cancer, headache, tumours, infertility etc. yet it was not accepted by a larger crowd. But the studies after 2005 reflected again and again the adverse effects of the cell phone radiation. Today the radiation effects are well proved and the standards of radiation, used in different countries, does not ensure safety. So the tolerable limits of EMR should be decreased to avoid a serious health hazard and while making the standards the governing bodies should take into account the long term effects of electromagnetic radiations.

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