

Government of India
Ministry of Communications & Information Technology
Department of Telecommunications

REPORT OF THE
INTER-MINISTERIAL COMMITTEE
ON
EMF RADIATION

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Committee

An Inter-ministerial committee consisting of officers from Department of Telecom, Indian Council of Medical research, Ministry of Health, Department of Biotechnology and Ministry of Environment and Forest was constituted to examine the effect of EMF Radiation from base stations and mobile phones:

- | | | |
|-------|------------------------------------|------------------|
| i) | Advisor (Technology) ... | Chairman |
| ii) | Sr. DDG (BW), DoT - | Member Secretary |
| iii) | Scientist ICMR, Ministry of Health | Member |
| iv) | Advisor, Dept. of Bio-technology | Member |
| v) | Scientist 'E', MOEF | Member |
| vi) | DDG (R) TEC, DoT | Member |
| vii) | Jt. Wireless Adviser, WPC, DoT | Member |
| viii) | DDG (CS), DoT | Member |

Terms of Reference of the Committee

1. Effect of RF radiation emitted by cell phone towers and mobile hand-sets on human health at levels below the existing standards.
2. Proliferation of electromagnetic field on environment.
3. Examination of the scientific evidence and research on the effect of electromagnetic radiation exposure from cell phone tower and from Mobile handsets conducted by Medical Council or other bodies in India and abroad.
4. Adoption of reference levels for power density from base stations in mobile frequencies of IMT bands for limiting electromagnetic field exposure in telecom sector in India.
5. Adoption of safety limits for exposure to radio frequency energy produced by mobile hand-sets i.e. Specific Absorption Rate (SAR) levels of exposure from a mobile hand-set and disclosure of information for the hand-set.
6. Any other suggestions/ measures to be taken on EMF radiation from cell phone towers and mobile hand-set.

Proceedings

Members of the committee deliberated on the issue on 08.09.2010, 27.09.2010, 08.10.2010 and 25.11.2010. Scientist from ICMR gave presentation to the committee on biological effects and on environmental issues. Prof. J. Behari, an expert made presentation on the research works undertaken in the School Of Environment Sciences, JNU giving a deep insight of the issue.

Representative of Telecom Equipment Manufacturers Association (TEMA), Cellular Operators Association of India (COAI), Telecom Users Group Of India (TUGI), Consumer Care Society (CCS), Bangalore and Prof. Girish Kumar, IIT, Bombay have also presented their view points on the issue on 08.10.2010.

The Ministry of Environment & Forests, (Wild Life Division) has constituted a committee to assess the level of possible impacts of growth of mobile towers in Urban, Sub-urban and even rural/forest area on the population of birds and bees and to suggest appropriate mitigative measures on 30/08/2010. The scientists assisting in the said committee attended the meeting on 25.11.2010.

General

The radio frequency sources in India are the transmitting towers such as AM, FM radio towers, TV towers, Cell phone towers, etc. emit radio frequency/ microwave radiation continuously. The level of EMF from sources has risen exponentially, by soaring popularity of wireless technology such as cell phones, cordless phones, Wi-Fi (Wireless Internet) Wi-max and other wireless devices. A cell phone that is 'ON' but not in use also radiates.

1.1 The radio frequency (R.F.) sources in India are: -

S.No.	R. F Source	Operating Frequency	Transmission Power	Numbers
1	AM/FM Tower	540 KHz-108 MHz	1 KW-300 KW	380
2	TV Tower	48 MHz-814 MHz	10-500 Watt	1201
3	Wi-Fi	2.4 – 2.5 GHz	10-100 mW	--
4	Cell Towers	800, 900 , 1800, 2450 MHz	20 W	5.4 Lacs
5	Mobile Phones	GSM-1800/CDMA GSM-900	1 W 2 W	700+ Million

1.2 The above RF sources have altered the landscape of human beings in countless beneficial ways, however created the environmental exposures to electromagnetic radiation (EMR) or Electromagnetic fields.

1.3 Electric fields are created by differences in voltage: the higher the voltage, the stronger will be the resultant field. Magnetic fields are created when electric current flows: the greater the current, the stronger the magnetic field. The Electromagnetic field (EMF) can be viewed as the combination of an electric field and a magnetic field.

1.4 Base Transceiver Stations (BTS) of Mobile Communication Network produce electromagnetic fields. These RF fields are used to transmit

information over long distances. Similarly Mobile Handsets also produce Electromagnetic radiations.

1.5 Frequency of the signal radiated from these sources determines important characteristics of electromagnetic fields. The electromagnetic fields emission from mobile handsets and BTS are found at relatively low end of electromagnetic spectrum and the energy carried by them are unable to break chemical bonds in molecules and are called non-ionizing radiation.

1.6 There has been unprecedented growth in the communication industry in recent years causing a dramatic increase in a number of communication towers to 5.4 lakhs in India and more and more towers are being erected each year.

1.7 Exposure from base stations: -

Mobile phone base stations are radio transmitter with antennas mounted on either free standing masts or on the buildings. Radio signals are fed through cables to the antennas and then launched as radio waves into the area or cell around the base station. Several types of antennas are used for the transmission; panel-shaped sector antennas or pole shaped Omni-antennas are used to communicate with mobile phones. Disk antennas form terminals for point to point microwave links that communicate with other base stations and link the network together. Sometimes the base stations are connected together with Optical Fiber cables (OFC) instead of microwave links. Depending on the location of the base station and the level of mobile phone uses to be handled, base station may be anything from only a few hundred meters apart in major cities to several kms apart in the rural areas.

1.8 Types of Base Stations:-

There are many different types of base stations used by operators i.e macro cell, micro cell or pico cell. Categorization is based on the purpose of the site rather than in terms of technical constraints such as radiated power or antenna height. In India macro cellular base station provide the main

infrastructure for a mobile phone network and their antennas are mounted at sufficient height to give them a clear view over the surrounding geographical area.

Micro cell base stations provide additional radio capacity where there are a high number of users such as in cities and towns. Micro antennas tend to be mounted on street level poles or external walls of existing buildings. Micro antennas are similar to macro cell antennas technically of smaller capacities. The power of each base station transmitter is set to a level that allows a mobile phone to be used within a area for which the base station is designed to provide coverage. Higher powers are needed to cover larger cells. The maximum power for individual macro cellular base station transmitter is 20 watt. For a low capacity base station with only one transmitter the radiated power does not vary over time. With larger capacity base stations having multiple transmitters the output power can vary over time and with the numbers of calls being handled. One of the transmitters will transmit continuously at full power, whereas other transmitter will operate intermittently and with varying power levels up to the maximum. Micro cellular base stations tend to operate at lower power level around 2-3 watt and have fewer transmitters because of their smaller coverage area.

1.9 For installation of mobile towers the Standing Advisory Committee on Radio Frequency Allocations (SACFA) clearances are issued by the wireless monitoring organization, DOT after getting no objection from defence & airport authority considering aviation hazards, obstruction to line of sight of existing/ planned networks and interference EMI/EMC. In India, there is no restriction on the location of the towers leading to a situation of jumble of towers / antennas all throughout. There is mushroom growth of mobile tower infrastructure seen which is contrary to the practice in developed countries.

1.10 Electromagnetic radiation in commercial land mobile service in Telecom sector is classified in two categories:

- (i) **Radiation from Base Transceiver Stations (BTSs)** of GSM, CDMA, 2G, 3G for Mobile Communication Network and of Wimax for Wireless Broadband Access.
- (ii) **Radiation from Mobile Handsets** used for communication and broadband access which are held in close contact with the user public.

1.11 The factors attributed to EMF radiation are:-

- Frequency / wavelength of RF signal being transmitted;
- Operating power of transmitting stations;
- Radio Frequency Power radiated from the antenna;
- Time of Exposure of RF signal at a given distance from the antenna ;
- Exposure from other antennas located in the Area;
- Over powering of amplifier for better reception quality, signal strength and more coverage;
- Duration/ frequency of recurrent exposure ;
- Age, size and portion of the body and
- Temperature and humidity.

1.12 As technology progresses and data demands have increased on mobile network, towns and cities have seen a number of towers increase sharply including 3G towers which work with larger bandwidths. Further as the costs of mobile technology have fallen, their uses have increased dramatically and the overall levels of exposure of the population as a whole have increased drastically.

1.13 Quite a number of law suits and writ petitions have been filed by individuals / groups alleging health effect of radiation. There is a need to evolve the alternative means to deploy mobile telecom network based on best International practices and for a National Policy and guidelines on EMF radiation for telecom towers.

1.14 Measurement of radio waves:-

There are various instruments available of radio wave strength and these vary in the degree of their technical capabilities. Hand held survey probes for measuring power density are the simplest equipment used for measurement. The equipment consist of a set of measuring antenna mounted on tripods connected to the spectrum analyzers which measure the signal strengths and passes the data to a computer. The total exposure due to all radio signals acting together is calculated. Normally, the measurements are made over the frequency range 30 MHz to 3000 MHz and the results include signals from radio, television as well as base stations. It is possible to break down the exposure quotient into proportions arising from different transmitters. Operators should calculate compliance distances in various directions from their antenna in order to define a boundary outside where the guidelines can never be exceeded.

Effect on human health

Studies have shown that human beings are bio electrical systems. The heart and the brain are regulated by internal bioelectrical signals. Environmental exposures to EMF can interact with fundamental biological processes in the human body and in some cases this may cause discomfort as reported in literature.

2.2 In a human body due to the proximity of a mobile phone to the head, the head is the targeted recipient of the electro-magnetic energy from many wireless systems whose impulses are transmitted to other organs and parts. A high frequency signal modulated at certain low frequency or a signal i.e. pulsed may have harmful effects than an un-modulated study carrier, as reported in literature.

2.3 Modulation signals are one important component in the delivery of EMF signals to which cells, tissues, organs and individuals can respond biologically. Modulating signals have a specific beat defined by how the signal varies periodically over time. Modulation signals may interfere with normal, nonlinear biological functions, as reported.

2.4 There have been growing public concern of possible adverse health effects due to EMF Radiation. The area of concern is the radiation emitted by the fixed infrastructure used in mobile telephony such as base stations and their antennas, which provide the link to and from mobile phones. This is because, in contrast to mobile handsets, it is emitted continuously and is more powerful at close quarters. The field intensities drop rapidly with distance away from the base of the antenna because of the attenuation of power with the square of distance. Following the enormous increase in the use of wireless telephony, mobile phone radiation and health concerns are being raised from time to time.

2.5 The effects of EMF radiation can be studied in two ways i.e. bio effects and health effects: -

- (i) Bio effects are measureable responses to a stimulus or to a change in the atmosphere and are not necessarily harmful to our health.
- (ii) Health effects are the changes which may be short term or long term. These effects stress the system and may be harmful to human health.

There are two distinct possibilities by which the Radio Frequency Radiation (RFR) exposure may cause biological effects. There are thermal effects caused by holding mobile phones close to the body. Secondly, there could be possible non-thermal effects from both phones and base stations.

a) Thermal Effects:-

One effect of microwave radiation is dielectric heating, in which any dielectric material, (such as living tissue) is heated by rotation of polar molecules induced by the *electromagnetic* field. The thermal effect has been largely referred to the heat that is generated due to absorption of EMF radiation. In the case of a person using a cell phone, most of the heating effect occurs at the surface of the head, causing its temperature to increase by a fraction of a degree. The brain blood circulation is capable of disposing the excess heat by increasing the local blood flow. However, the cornea of the eye does not have this temperature regulation mechanism. The Thermal effect leads to increase in body temperature.

b) Non-Thermal Effects:-

The communication protocols used by mobile phone often result low frequency pulsing of the carrier signal. The non-thermal effect is reinterpreted as the normal cellular response to an increase in temperature.

The Non-thermal effects are attributed to the induced electromagnetic effects inside the biological cells of the body which is possibly more harmful. People who are chronically exposed to low level wireless antenna emissions and users of mobile handsets have reported feeling several unspecific symptoms during and after its use, ranging from burning and tingling sensation in the skin of the head, fatigue, sleep disturbance, dizziness, lack of concentration, ringing in the ears, reaction time, loss of memory, headache, disturbance in digestive system and heart palpitation etc. There are reports indicating adverse health effects of cell phones which emit electro-magnetic radiation, with a maximum value of 50% of their energy being deposited when held close to the head.

2.6 The effects of long term exposure to wireless technology including emissions from cell phones and whole body exposure to RF transmission from cell tower antenna is simply not known yet with certainty. Scientific studies as yet have not been able to confirm a cause-and-effect relationship. The research has not so far separated these symptoms from electromagnetic radiation hence all the above symptoms can also be attributed to stress.

2.7 Member Scientist, ICMR has indicated that the hot tropical climate of the country, low body mass index (BMI), low fat content of an average Indian as compared to European countries and high environmental concentration of radio frequency radiation may place Indians under risk of radio frequency radiation adverse effect.

Effect on Environment

The most pervasive environmental exposure in industrialized countries today is the Electro Magnetic Radiation (EMR) or Electro Magnetic Fields (EMFs) exposures created by the vast array of wireless technologies.

3.1 Environment represents the totality of physical, chemical, biological, behavioral and socio-economic factors. The electromagnetic radiation pervading the environment is now increasingly realized and this has added to the list of another pollutant in the environment i.e. electro-pollution.

3.2 Some Studies reported that mortality at communication towers over 200 ft. may be a threat to the healthy population of birds and electromagnetic radiation from cell phone towers may probably be the reasons for the vanishing butterflies, bees, insects and sparrows. Some other Studies have also shown that there seems to be effects on birds exposed to the electromagnetic field radiation and losing navigational ability. They get disoriented and begin to fly in different direction. (Gavin, Karen and Gerald 2000⁵⁸: Joris and Dirk 2007⁸³: Andrews, 2007⁸⁴). However the committee notes that these studies were unable to find a direct link of exposure of EMF radiation to adverse effects on birds.

3.3 The Ministry of Environment & Forests, (Wild Life Division) has constituted a committee on 30th August 2010 to assess the level of possible impacts of growth of mobile towers in Urban, Sub-urban and even rural/forest area on the population of birds and bees and to suggest appropriate mitigative measures to address to the problem.

3.4 For monitoring of the proliferation of EMF radiation, provision of ambient EMF radiation monitoring network may be considered on the line of national ambient air monitoring network, ambient noise monitoring network, weather monitoring stations, etc.

Scientific evidence and research

World Health Organization (WHO)⁹⁰ reported that “considering the very low exposure levels and research results collected, there is no convincing scientific evidence that the weak RF signals from cell phone towers and wireless networks cause adverse health effects”. Mobile phones communicate by transmitting radio frequency waves are electromagnetic fields, and unlike ionizing radiation such as X-rays or gamma rays, cannot break chemical bonds nor cause ionization in the human body.

However a number of studies have reported the link between exposure to radio frequency radiation and occurrence of health disorder i.e. effect on cell growth, cell differentiation, DNA, immune system, hormonal effects, reproduction, neurological, cardiovascular systems, blood brain barrier, interference with gadgets, stress proteins, skin, sleep disorder etc. As these studies were not well designed and the number was not statistically significant, these observations have not been considered conclusive.

4.1 Member Scientist ICMR referred to some of the studies of adverse effect on human health as below:

- (i) Cleary et al (1990a)²³ carried out series of experiments on cell proliferation and cell kinetic studies under continuous wave Radio Frequency Radiation (RFR) exposures and reported increased proliferation. They also observed similar effects in human peripheral lymphocytes (Cleary et al 1990 b)²⁴.

- (ii) RFR has been shown to down-regulate gap-junctional intercellular communication, which plays an essential role in regulation of cell growth, differentiation and wound healing (Chiang, 1998)⁴⁶.

- (iii) RFR have been reported to affect a variety of ion channel properties, such as decreased rates channel protein formation, decreased frequency of single channel opening and increased rates of rapid burst-like firing (Repacholi, 1998)⁴⁴. Even Ca^{2+} release from cell membrane has been reported (Dutta et al 1984¹³; Bawin et al 1975³). An increase in calcium dependent protein kinase C has been noted in developing rat brain indicating that this type of radiation could affect membrane bound enzymes associated with cell signaling, proliferation and differentiations (Paulraj & Behari 2004)⁷⁰.
- (iv) RFR have been shown to affect the kinetics of conformational changes of the protein beta-lacto-globulin and it can accelerate conformational changes in the direction towards the equilibrium state, which applies both for the folding and the unfolding process (Bohr & Bohr, 2000)^{55, 56}.
- (v) In experimental animals an increase in the blood brain barrier permeability in response to exposure to RFR has been reported in a number of studies (Albert 1977⁷; Oscar & Hawkins, 1977⁶; Fritze et al 1997^{40,41}). Resting blood pressure has been reported to increase during exposure to RFR emitted from cell phones (Braune et al 1998)⁴⁷. The RFR emitted from cell phones are also reported to decrease significantly the slow brain potentials (SP) which is very important to the stage of information processing related to getting ready or prepared for an activity to reach a particular goal (Gabriele et al, 2000)⁵⁴.
- (vi) DNA rearrangement in cells from brain and testis were reported under RFR exposure at low intensity in mice (Sarker et al, 1994, 1996)^{30, 34}.

- (vii) Increased dominant lethal mutations in the offspring of exposed male mice and abnormal sperm were also reported in mice (Verma et al, 1976⁴; Verma & Traboulay, 1976⁵; Goud et al, 1982¹⁰) but such effects were not seen in rats (Berman et al, 1980)⁹ and C3H mice (Saunders et al, 1983, 1988)^{11, 18}.
- (viii) While increased chromosomal aberrations have been reported in large number of studies (Yao and Jiles, 1970¹; Chen et al, 1974²; Garaj Vrhovac et al, 1991²⁵, 1992²⁶; Khalil et al, 1993²⁸; Maes et al 1993²⁷, 1995^{31a}; Tice et al 2002⁶⁴), some other studies did not find such aberrations (Meltz et al, 1987¹⁶; Kerbacher et al, 1990¹⁹). Occurrence of increased micronuclei, which is another indirect indicator of DNA damage, has been reported in large number of studies (Antipenko and Koveshinkova 1987¹⁷; Maes et al, 1993²⁷; Haider et al 1994³¹; Balode 1996³⁷; Garaj Vrhovac 1999⁴⁹).
- (ix) Robinette et al (1980)⁸ reported increased frequency of blood cancer and brain cancer in US naval personnel exposed to RFR (wireless, other radio-communication) during Korean War and followed for about twenty years.
- (x) Garland et al (1990)²¹ reported a link between leukemia in US navy personnel and exposure to higher intensity of magnetic fields.
- (xi) Grayson (1996)³⁵ reported brain cancer in US Air Force personnel and found that nonionizing radiation particularly microwave exposure had statistically significant association.
- (xii) Thomas et al (1987)¹⁵ reported an increased risk of brain tumor death in men ever employed in an electronics occupation.

- (xiii) Tynes et al (1996)³³ reported increased breast cancer risk among female radio and telegraph operators.
- (xiv) Leukemia mortality was found to be higher than expected near a high power radio transmitter in a peripheral area of Rome (Michelozzi et al, 1998)⁴⁵.
- (xv) A cluster of six cases of testicular cancer was reported among traffic policemen using microwave generators (Davies and Mostofi 1993)²⁹.
- (xvi) Hayes et al (1990)²⁰ reported excess risk of testicular cancer among Military personnel who self reported exposure to microwaves and radio waves.
- (xvii) Karolinska Institute, Stockholm reported increased risk of developing acoustic neuroma in peoples using cell phone for more than 10 years (EIRIS, 2005)⁷⁶.
- (xviii) Lennart Hardell et al (2001, 2005, 2006, 2007 & 2009)^{63, 74, 78, 79, 87} conducted number of epidemiological studies as well as case control studies on use of mobile phones for more than 10 years. They reported that the use of mobile phones for more than 10 years give a consistent pattern of increased risk for acoustic neuroma and glioma. The risk is highest for ipsilateral exposure. They further reported that longer follow-up is needed and an increased risk for other type of brain tumors cannot be ruled out.
- (xix) Goldoni (1990)²² compared the hematological finding in 25 male air traffic control technicians working at a distance from microwave sources and reported that radar exposed workers had significantly

lower levels of leukocytes and red cells than the electronic technicians.

(xx) Electrocardiographic abnormalities were detected significantly more frequently in workers exposed to electromagnetic field than in non-exposed subjects (Bortkiewicz et al, 1997)⁴².

(xxi) RF fields are also reported to triggered immune system response similar to those resulting from thermal stress (OPHA, 2003)⁶⁷. Adverse effects on the immune system can indirectly predispose to infection to cancer (RSC, 1999)⁴⁸.

(xxii) Inconclusive results have indicated a possible change in the blood-brain barrier permeability under the influence of RF field changes in the brain electric activity, in the release of neurotransmitters, in melatonin secretion, and in the retina, iris and corneal endothelium have been reported in animals (OPHA, 2003)⁶⁷. The effects on nervous system include behavioral, cognitive (Hermann & Hossmann, 1997)³⁹ neurochemical (Mausset et al, 2001)⁶² and neurological (Beason & Semm 2002)⁶⁶ effects in human and laboratory animals (Hamblin & Wood, 2004⁷², Tattersall et al., 2001⁵⁹).

(xxiii) Kowalczuk et al (1983)¹² reported reduction in male fertility coupled well with reduced pregnancy rate in male mice exposed to RFR for 30 min. On the other hand Beechey et al (1986)¹⁴ and Dasdasi et al (1999)⁵⁰ did not observe any decrease in sperm count and also no difference in sperm morphology in rates exposed to RFR emitted by cell phone. However Dasdag et al (1999)^{50, 51} found significant changes in testicular histopathology (reduction in seminiferous tubul diameter) and increase in rectal temperature in these rates.

(xxiv) Semen analysis of military personal associated with potential RFR exposure showed lower sperm count than control group (Danulescu et al, 1996³⁶; Weyandt et al, 1996³²; Schrader et al, 1998⁴³). Differences in semen quality and hormone levels have also been observed in RFR dielectric heater operator (Grajewsk et al, 2000)⁵³.

4.2 **Studies reported impact of cell phone towers :**

(xxv) Santini et al. (2002)⁶⁵ reported significant health effects on people living within 300 meters of mobile phone base stations in Paris particularly in relation to depressive tendency, fatigue, sleeping disorder and difficulty in concentration.

(xxvi) Netherlands Organization for Applied Scientific Research, TNO, (2003) studied the effects of Global Communications System Radio-Frequency Fields on Well Being and Cognitive Function of Human Subjects with and without Subjective Complaints and reported significant effects on wellbeing of the people i.e, headaches, muscle fatigue/pain, dizziness etc from 3G mast emissions. Those who had previously been noted as 'electro-sensitive' under a scheme in that country were shown to have more pronounced ill-effects, though others were also shown to experience significant effects.

(xxvii) Spanish : Oberfeld Gerd et. al. (2004)⁷¹ from Spain reported significant ill-health effects in 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.

(xxviii) Israel : Ronni Wolf & Danny Wolf (2004)⁶⁹ from Israel, based on medical records of people living within 350 meters of a long-established phone mast, reported a fourfold increased incidence of cancer in comparison with the general population of Israel. They also

reported a tenfold increase specifically among women, compared with the surrounding locality further from the mast

(xxix) Germany (November 2004) : The bases of the data used for the survey were PC files of the 1000 patient's case histories between the years 1994 and 2004. The authors reported that the proportion of newly developing cancer cases was significantly higher among those patients who had lived during the past ten years at a distance of up to 400 meters from the cellular transmitter site, which has been in operation since 1993, compared to those patients living further away, and that the patients fell ill on average 8 years earlier.

(xxx) Austria 2005 : When Electro sensitive men (3) and women (9) were exposed to RFR emitted from a shielded cell phone base station in phase manner all of them reported symptoms like buzzing in the head, palpitations of the heart, un-wellness, lightheadedness, anxiety, breathlessness, respiratory problems etc. This study shows significant changes of the electrical currents in the brain by a cell phone base station at a distance of 80 meters.

The committee notes that most of the laboratory studies were unable to find a direct link between exposure to RFR and the incidence of cancer. However, growing scientific evidences of bio effects and adverse health effects like DNA rearrangement in cells or chromosomal damage is reported. (Sarkar et al 1997³⁸; Sarkar and Selvamurthy 2001⁶⁰). Even the biological effects could not be established as caused by Radio Frequency Radiation, due to complex interaction of the different exposure parameters i.e. mass, shape and size of the body (age, gender, activity level, body insulation etc.) and the environmental conditions (ambient temperature, air velocity, humidity).

4.3 **Studies being conducted in India: -**

- (i) I
Indian Council of Medical Research (ICMR) supported an animal study (2005-08) entitled "Microwave radiations effects on reproductive systems of male rats" under Prof. J. Behari, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi. Ante oxidative changes were noticed in reproductive pattern of male rats and increase in the level of CAT activity. The result obtained showed that the chronic exposure to these radiations cause double strand DNA breaks in sperm cells. This study also shows that the microwave radiation exposure can cause statistically significant decrease in the sperm count and testes weight.
- (ii) T
To study the adverse effects of cell phone the ICMR has just initiated (June, 2010) a study in Delhi to examine whether use of cell phone create risk of neurological disorders and reproductive dysfunctions. Measurement of specific absorption rate (SAR) from various types of cell phones and power density, wave length and frequency of RFR emitted from cell phone towers is also under study. These physical characteristics of RFR will be correlated with the clinical & laboratory findings.
- (iii) S
Studies conducted in Guru Nanak Dev University, Amritsar has found correlation between mobile phone use (exposure to radio frequency radiations) and DNA and chromosomal damage in lymphocytes of individuals using mobile phones which may have long-term consequences in terms of neoplasia and/or age-related

changes (Gandhi & Anita, 2007)⁸⁰. Exposure to radiofrequency radiations has been reported to affect physiological, neurological, cognitive and behavioral changes. (Gandhi et al. 2005)⁷⁵.

(iv)

P

GIMER, Chandigarh, has conducted a study (Panda et al., 2010)⁸⁹ and recommended following criteria's for the release of harmful rays from mobile phones.

- Mobile phones should not be used continuously for more than one hour in a day.
- Hands free technology to be used where excessive use of the mobile phone is unavoidable. This includes use of microphones and Bluetooth so that the handset remains away from the ear and thus avoids the direct impact of harmful electromagnetic radiations on the ear and the brain.
- People to avoid long talks and discussions on mobile phones as far as possible.

4.4 The references of case studies are placed at end of the report.

EMF Exposure Limits
From
Mobile Base Stations

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an international independent scientific organization that provides guidance and advice on the health hazards of non-ionizing radiation exposure. ICNIRP has published guidelines for limiting exposure to time varying electromagnetic fields in the frequency range up to 300 GHz. Its guidelines are endorsed by the World Health Organization (WHO).

5.1 India has adopted the following ICNIRP guidelines for basic restrictions and reference levels for limiting Electromagnetic fields exposure in the

Type of exposure	Frequency range	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power density (W/m)
General Public	400-2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$f/200$
	2-300 GHz	61	0.16	10

Telecom Sector.

The existing standards are based on thermal (heating) limits and do not address non-thermal (or low intensity) exposures which are reported to cause Biological effects. The present ICNIRP / FCC limits are insufficiently protective of public health and require reconsideration.

5.2 Some countries in the world have specified for their own radiation level keeping in view the environmental and physiological factors. In order to protect the population living around base stations and users of mobile handsets, established new, low intensity based exposure standards. The new exposure guidelines are hundreds or thousands of times lower than those of

Institute of Electrical & Electronics Engineers (IEEE), USA and ICNIRP. The exposure limit for RF field of some of the countries including countries that have lowered their limit, in cell phone frequency range of 900 MHz and 1800 MHz for example are as given under :-

Table – 1: International Exposure Standards

International Exposure limits for RF fields (1800 MHz)	
12 W/m ²	USA, Canada and Japan
9.2 W/m ²	ICNIRP and EU recommendation 1998 – Adopted in India
9 W/m ²	Exposure limit in Australia
2.4 W/m ²	Exposure limit in Belgium
1.0 W/m ²	Exposure limit in Italy, Israel
0.5 W/m ²	Exposure limit in Auckland, New Zealand
0.45 W/m ²	Exposure limit in Luxembourg
0.4 W/m ²	Exposure limit in China
0.2 W/m ²	Exposure limit in Russia (since 1970), Bulgaria
0.1 W/m ²	Exposure limit in Poland, Paris, Hungary
0.1 W/m ²	Exposure limit in Italy in sensitive areas
0.095 W/m ²	Exposure limit in Switzerland, Italy
0.09 W/m ²	ECOLOG 1998 (Germany) Precaution recommendation only
0.001 W/m ²	Exposure limit in Austria

5.3 Following are the reference levels based on international and national guidelines.

Table – 2: Reference levels for the general public at 900 & 1800 MHz.

Country or Organization	Document	900 MHz		1800 MHz	
		Electric field (V/m)	Power density W/m ²	Electric field (V/m)	Power density W/m ²
International health based guidelines					
International commission of non ionizing radiation protection	ICNIRP 1998	41.25	4.5	58.3	9.0
International/ Institute of Electrical and Electronics Engineer	IEEE,1999 USA	47.6	6.0	67.3	12
European/ European Committee for Electro technical Standardization (Technical committee)	CENELEC,1995	41.1	4.5	58.1	9.0
National health based guidelines					
Australia/ Standard Association of Australia	AS/NSZ, 1998	27.5	2.0	27.5	2.0
East European health based guidelines					

Hungary/ Hungarian Standard Institution	Hungary, 1986	6.1	0.1	6.1	0.1
National guidelines based on precautionary approaches					
--	Belgium ^a	20.6	1.1	30	2.4
Italy/ Ministry of Environment	Italy 1, 1998 ^b	20	1.0	20	1.0
Italy/ Ministry of Environment	Italy 2, 1998 ^b	6	0.1	6	0.1
Switzerland/Schweizer Bunnedesrat	NISV, 1999	4	0.04	6	0.1
Local recommendations, based on precautionary approaches					
Austria Local	S vorGW 1998	0.6	0.001	0.6	0.001

5.4 Bio-initiative report^{84a} published in US contains biologically based public exposure standards for electromagnetic fields at different radio frequencies. Bio-initiative report 2007 recommended 1000 $\mu\text{W}/\text{m}^2$ for outdoor cumulative RF exposure and power density limit up to 50 $\mu\text{Watt}/\text{m}^2$ with upper limit as 100 $\mu\text{Watt}/\text{m}^2$.

5.5 In absence of any conclusive scientific evidence of adverse effect of EMF radiation on human health, India is following the ICNIRP EMF standards. While framing the standards for EMF radiation limitation levels by ICNIRP, the assumptions made and other conditions that might have been considered like population density, socio-economic factor may not be commensurate with the Indian conditions. Stricter radiation norms are being followed in different countries and they have specified for their own radiation level keeping in view the environmental and physiological factors varying from 0.001 Watt/ m^2 to 2.4 Watt/ m^2 at 1800 MHz operating frequency (Table I) where as in India the prescribed reference level at 1800 MHz is 9.2 Watt/ m^2 .

5.6 The hot tropical climate of the country, low body mass index (BMI), low fat content of an average Indian as compared to European countries and high environmental concentration of radio frequency radiation may place Indians under high risk of radio frequency radiation adverse effect and the level of susceptibility of an average Indian may be different. Hence revision of radiation norms may be considered for adoption in India keeping in view the possible health concern.

5.7 The field measurement under taken by the Cellular Operator Association of India in Metro cities like Delhi, Chennai and Mumbai have shown that the measured values are hundreds of time lower than that of the prescribe reference level. It is important that safety standards be rational and avoid excessive safety margins. To establish rational standards that will make future safer, the RF exposure limits in India may be lowered to 1/10th of the existing reference level.

5.8 There is a need to evolve the alternative means to deploy mobile telecom network based on best International practices. Low power cellular base station would require much smaller exclusion zone than existing cells and Use of such transmitters inside cities will decrease the amount of radiated power.

5.9 The committee was of the view to visit one or two countries having demographical similarity to study the monitoring network, monitoring mechanism, compliance mechanism and guidelines of countries before finalizing the radiation level guidelines in India. However due to paucity of the time this could not be studied.

Exposure Limits
for
Mobile hand-sets

The radio waves emitted by GSM handset have a peak power of 2 watts and other digital mobile technologies such as CDMA and D-AMPS use lower output power, typically below 1 watt. In most systems the cell phone and the base station check reception quality, signal strength and the power level is increased or decreased automatically, within a certain span, to accommodate for different situations such as inside or outside the buildings and vehicles. As the phone moves closer to the base stations, the power emitted from the phone antenna is reduced.

6.1 Specific Absorption Rate (SAR) is a measure to know the levels of exposure to electromagnetic fields from mobile handsets. It the rate at which human body absorbs electromagnetic power radiated from mobile phones.

6.2 India has adopted the following ICNIRP guidelines as standard for safety limits of exposure to radiofrequency energy produced by mobile handsets :

	Whole-body average SAR (W/kg)	Localized SAR head and trunk (W/kg)	Localized SAR limbs (W/kg)
General Public Exposure	0.08	2	4

Note: - SAR values are averaged over a 6 minutes period using 10 gram average mass.

6.3 In the USA, the FCC has set a SAR limit of 1.6 watt per kg averaged over a volume of 1 gram of tissue, for the head. In Europe the limit is 2 watt per kg, averaged over a volume of 10 gram of tissue. SAR values are heavily dependent on the size of the averaging volume.

6.4 The cell phones and other wireless communication devices are regulated according to their emissions, which define the amount of power absorbed into the body. The metric for measurement is Specific Absorption Rate (SAR) expressed in Watts/ Kg of tissue.

6.5 Each body has a characteristic resonant frequency, depending upon the length of the long axis. For the same level of incident exposure the average SAR is dependent upon the length of the body. Thus the average body SAR is size and frequency dependent.

6.6 The standards adopted in US are most stringent which is prescribed by the Federal Communication Commission (FCC) of United States. The permissible SAR levels at or below 1.6 W/kg taken over a volume containing a mass of 1 gm of tissue, whereas for general public exposure the localized SAR value as per ICNIRP guidelines standard adopted in India is 2 W/kg, averaged over a 6 minute period and use a 10 gm average mass. With higher SAR values of mobile handset the public could potentially receive much higher radio frequency exposure.

6.7 As the costs of mobile phone technology have fallen, their use has increased dramatically and the overall levels of exposure of the population as a whole have therefore increased drastically. Keeping in view of the fact, the high population density, body mass index of a common Indian is lower than the European countries, and the fat content of an average Indian is also lower as compared to these countries, Indians are more susceptible towards the EMF radiation. Further when the handset operates at full transmitter power because of a long distance to the next base station, the local SAR values are reported to be in the range of 1 watt / kg. Hence we may consider adopting stringent standards in India i.e. the absorption of radio frequency radiation limited to 1.6 Watt/Kg within 1 gram of human tissue as per the FCC norms of United States.

6.8 Presently the SAR data information of the mobile hand sets are found on the manufacturer's web site or in the manufacturer's handset's manual and is not available on the mobile handsets. Information on SAR values for mobile handsets should be readily available to the consumer at the point of sale so that one can make sure of the SAR value of the handset while buying a cell phone. Hence we may consider that the SAR value information be embossed on the handsets.

6.9 Mobile hand set manufactured and sold in India or Imported from other countries should be checked for compliance of SAR limit and no hand sets of SAR value above the prescribed standard adopted in India should be manufactured or sold in the country. The Department of Telecom has requested BIS to frame standards for mobile phones so that import / manufacture of substandard mobile handsets can be regulated.

6.10 For making mandatory provisions and to regulate the SAR value of mobile handsets Government may consider amendment of Indian Telegraph Act 1885 and rules notified there-under and necessary legislations if any so that only mobile handset satisfying security standards should be permitted for import / manufacture or sold in the country.

6.11 Awareness of exposure can be accomplished by the use of warning levels or by education through appropriate means. The mobile handset booklet should contain the following for safe use :

- Use a wireless hands-free system (headphone, headset) with a low power Bluetooth emitter to reduce radiation to the head.
- When buying a cell phone, make sure it has a low SAR.
- Either keep your calls short or send a text message (SMS) instead. This advice applies especially to children and adolescents.
- Whenever possible, only use your cell phone when the signal quality is good.

- People having active medical implants should keep their cell phone at least 30 cm away from the implant at times.
- Using a mobile phone in a open area, not inside a vehicle so that the phone receives a good signal and transmits at lower level.
- Not using a mobile phone when a normal wired phone is available.

6.12 The SAR value information should be made available on the government website and the concerned regulatory agency with the list of SAR values of different mobile handsets.

Other Suggestions & Measures

There is a growing public concern of adverse effect of EMF radiation on health. Certain measures may have to be initiated for building confidence of general public as underlined below :

- (a) To provide static continuous testing / measuring centers for online monitoring of radiation level on 24X7 basis at prominent places in metro / cities and the data sent to the central server for further processing as is being done by the Ministry of Environment and Forest through Central pollution Control Board in case of Pollution level measurement i.e. noise and air quality to enhance the confidence of general public.
- (b) Apart from self certification for compliance of radiation norms on EMF exposure by the mobile service providers they may be asked to measure the radiation level of certain prominent places and display it for information of the general public.
- (c) The service providers should also have mobile unit for its measurement wherever necessary.
- (d) Creation of national data base with the information of all the base station, their emission levels and display on public domain for public information.
- (e) The information of the SAR value for mobile phone should be readily available to consumer at the point of sale.
- (f) The Information should be made available on Government website with list of SAR values of different mobile phones.
- (g) Use of low power transmitters inside cities decrease the amount of radiated power hence Use of low power transmitter with in-building solutions as provided in western countries may be considered in place of present trend of using high powered transmitters over high rise towers
- (h) Public education programme needs to be undertaken.

7.1 Steps may be taken to conduct the long term scientific research related to health aspect of EMF radiation exposure and associated technologies in the following areas :

- Health effect of RF exposure in children.
- Health effect of RF exposure in Foetus, mothers and elderly person.
- Combined electromagnetic field radiation effect exposure from multiple antennas of a shared infrastructure sites

7.2 Due to the wide spread use and economic importance of wireless communication system in modern civilization, there is increase in popularity of such wireless communication measures mentioned in earlier paras in general public, it is recommended for minimization of cell phone uses, limitation of use by children, adoption of cell phone and micro cell with ALARA (as low as reasonably achievable) levels of radiation, use of hands free and ear phone technologies such as blue tooth handsets, adoption of maximal standards of exposure, RF field intensity and distance of base stations antennas from human habitation and so forth.

7.3 Many countries have adopted the best practice in form of a document created by the ministry used for education of customers, duly highlighting the domain of radio wave protection. Department of Telecom may create a document "Radio waves and safety in our daily life" indicating various Dos and Don'ts related to mobile users clarifying various myths regarding deployment and use of radio waves and mandate each operator to print and issue the same to their customer at the point of sale for enhanced customer awareness. This will help in facilitating the right inputs and creating an environment where everyone can use the radio waves safely.

Recommendations

Mobile Handsets : -

1. Adoption of SAR level for mobile handsets limited to 1.6 Watt/Kg, averaged over a 6 minutes period and taken over a volume containing a mass of 1 gram of human tissue as per the FCC norms of United States.
2. SAR value information is to be embossed and displayed in the handset.
3. Information on SAR values for mobile handsets should be readily available to the consumer at the point of sale so that one can make sure of the SAR value of the handset while buying a cell phone.
4. Government may consider amendments in the **Indian Telegraph Act 1885 & rules notified there under** and necessary legislations if any so that only mobile handset satisfying radiation standards should be permitted for import / manufacture or sold in the country.
5. Mobile hand set manufactured and sold in India or Imported from other countries should be checked for compliance of SAR limit and no hand sets of SAR value above the prescribed standard adopted in India should be manufactured or sold in the country.
6. SAR data information of the mobile handsets should be available on the manufacturer's web site and in the manufacturer's handset's manual.
7. To bring awareness, the manufacturer's mobile handset booklet should contain the following for safe use :
 - a. Use a wireless hands-free system (headphone, headset) with a low power Bluetooth emitter to reduce radiation to the head.
 - b. When buying a cell phone, make sure it has a low SAR.

c. Either keep your calls short or send a text message (SMS) instead.

This advice applies especially to children, adolescents and pregnant women.

d. Whenever possible, use cell phone when the signal quality is good.

e. People having active medical implants should keep their cell phone at least 30 cm away from the implant.

8. The Information is made available on Government website with list of SAR values of different mobile phones.

Mobile Base Stations : -

9. The RF exposure limits in India may be lowered to $1/10^{\text{th}}$ of the existing level keeping in view the data submitted by COAI/ AUSPI during presentation made to the committee and trend adopted by other developed countries.

10. To provide static continuous testing / measuring centers for online monitoring of radiation level at prominent places in metro/cities and the data to be sent to the central server for information.

11. Apart from self certification for compliance of radiation norms on EMF exposure as is presently being done, the mobile service providers should also measure the radiation level of certain prominent places and display it for information of the general public. They should also have mobile unit for its measurement wherever necessary.

12. DOT should create a national data base with the information of all the base station, their emission levels and display on public domain for public information.

13. Impose restrictions on installation of mobile towers near high density residential areas, schools, playgrounds and hospitals.
14. For the future expansion of telecom network in the country use low power micro cell transmitters with in-building solutions in place of the present trend of using high power transmission over mobile towers / high rise buildings.
15. To conduct the long term scientific research related to health aspect of EMF radiation exposure and associated technologies in India in the following areas :
 - Health effect of RF exposure in children.
 - Health effect of RF exposure in Foetus, mothers and elderly persons.
 - Combined electromagnetic field radiation effect exposure from multiple antennas of a shared infrastructure sites
16. It is recommended for use of hands free and ear phone technologies such as blue tooth handsets and ear phone so as to minimize the contact of head with cell phone.
17. Department of Telecom may create a document "Radio waves and safety in our daily life" indicating various Dos and Don'ts related to mobile users clarifying various myths regarding deployment and use of radio waves and mandate each operator to print and issue the same to their

customer at the point of sale for enhanced customer awareness. This will help in facilitating the right inputs and creating an environment where everyone can use the radio waves safely.

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