

Comparative Study of RF Electromagnetic Field Exposure Standards

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Abstract— Nowadays it is necessary to know the different electromagnetic field exposure standards for getting the information regarding power density and electric field near to us. Since mobile phone is the integral part of the personal and daily life, electromagnetic field exposure from base stations is increased. Over the past eight to ten years, there has been a notable surge in wireless data traffic and the introduction of new communications technologies, leading to a rapid development of the technologies employed in mobile phones. This paper compares various electromagnetic field (EMF) exposure guidelines and examines radiofrequency electromagnetic field exposure estimates from base stations in the Kolhapur region. Exposure levels are measured in V/m and mW/m^2 for 15 selected sites from urban rural areas of Kolhapur using KM-195 exposure meter. Total 15 sites were selected for the measurement of power density and electric field. Summary and statistics of power density and electric field in milliwatt / m^2 and volt / m for each measurement area is done. Finally, all EMF exposure levels are compared with global standards. After comparing it is found that the stricter country in EMF exposure is Austria, its exposure level standard is $0.001 w/m^2$. It is very lesser than other countries. Followed by Austria the other stricter countries are Germany, Switzerland, Italy, Poland, Paris, Hungary, Russia and Bulgaria. Their EMF exposure levels are 0.09, 0.095, 0.1 and $0.2 w/m^2$ respectively.

Keywords— ICNIRP, mobile base station, Department of Telecom, ARP & SNA, Exposure standard

I. INTRODUCTION

In India the amount of mobile users are huge in number. To cover these users base station towers are required and those installed in residential area in rural and urban area of the country. Therefore people around and nearby area get exposed to electromagnetic radiation. If amount of radiation from base station is excessive or above the threshold level then people has to face the undesirable health effects due to this electromagnetic radiation. Many international organizations work together to determine the standard threshold level for electromagnetic radiation in the form of electromagnetic field and power density in order to manage this quantity of radio frequency (RF) radiation from the base station towers.Regarding the RF field radiated from mobile towers the awareness is more in European countries than Asian countries.

The purpose of the electromagnetic field exposure standards is to investigate the general electromagnetic (EM) field

exposure (outdoor), residential field exposure (indoor) and floor exposure near mobile base stations (MBS). And study of unfavorable biological health issues on creatures around MBS or antenna mast due to EM radiation from it. the measurement and analysis of outdoor EM field from MBS can be performed in the form of power density and electromagnetic field, hence EMF exposure standards are set in the form of power density and electromagnetic field. EM field exposure is measured on sunny days. Contribution of each MBS is more. In general the height of antenna tower is about 125 feet. Additionally, there were roughly 16 typical antennas installed on antenna masts. All measured EM field values were compared with local and worldwide standards i.e. DoT and ICNIRP. The objective of outdoor field assessment is to determine EM field from MBS in citizens and its analysis. All measured outdoor EM field values were sufficiently lower than reference standard values set by ICNIRP but above standard of Austria [1]. Electromagnetic radiations changes every day which is radiated from base station i.e. radiated power density is not same among different base stations but it depends upon the number of instantaneous calls. Till date there is less awareness in Indian society regarding EM exposure from base stations, its unfavorable health issues, EM exposure rules etc.

II. GLOBAL STANDARDS

Worldwide organizations such as WHO, ICNIRP (world health organization), NRPB (National Radiological Protection Board), European counsel, ARPANSA and CENELEC were set the reference standard for EM field radiated from base stations. Our country following the guidelines set by national standard i.e. DoT (Department of Telecomm) which are based on ICNIRP. Assessing EM field exposure in urban and rural areas of Kolhapur district is a challenging task. After calculation of EM field exposure, it is essential to check whether there is compliance with worldwide standards? Whether this EM field is well below the reference standard set by worldwide organizations or not? Therefore, investigation on outdoor, indoor, and floor EM field exposure is essential [2][3].

There are organizations worldwide which are working on power density from MBS. It works to defend the citizens from extreme electric field from MBS by providing standard EM field energy norms. Different worldwide organizations working on EM field are IRPA, ICNIRP, ARPANSA, CENELEC, and WHO etc. which has examined problems arising in EM field and how to protect from NIR [4][5].

European community prepared guidelines / rules for EM field from MBS in July 99. Some of important guidelines/rules are

- To protect citizens from unfavorable health issues.
- EM fields must have a safe level so that people living near base stations will get a high amount of protection.
- To bring the quality of life in people, reduce EM radiation from MBS.

A. ICNIRP standard

The main task of ICNIRP is to prepare the rules for controlling the exposure to EMFs that will provide a higher level of protection for society against excessive EM radiation. ICNIRP is main worldwide body to control and protect society from NIR. It consists of technical as well as consulting experts. The key purpose of this body is to study various unfavorable health issues due to NIR from mobile base stations. Also it spreads information of health issues and suggestions to common persons. They set safety guidelines cum standard for NIR from MBS [1][6]. The goal of the ICNIRP regulations is to safeguard the public against radiofrequency electromagnetic fields (emfs) that operate in the frequency range of 100 KHz to 300 GHz. As per ICNIRP standard, worldwide EM power density values are as follows.

TABLE I. REVISED EM FIELD EXPOSURE LIMITS

Worldwide power density standard at 900 MHz	
Power density in W/m ²	Country
0.45	India
0.45	ICNIRP
6.0	Japan, USA, Canada
2.0	Australia
1.1	Belgium
1.0	Italy, Israel
0.5	New Zealand and Auckland
0.45	Luxembourg
0.4	China
0.2	Bulgaria and Russia
0.1	Poland, Paris, Hungary
0.1	Italy
0.095	Switzerland
0.09	Germany
0.001	Austria

DoT revised their NIR standards in 2012 for telecomm frequencies in India. Following table shows operating frequencies and their corresponding standard power density value [8].

TABLE II. REVISED EM FIELD EXPOSURE LIMITS

Frequency in MHz	ICNIRP old power density standard (W/ m ²)	Indian standard for different frequencies (W/ m ²)
900	4.5	0.45
1800	9	0.9
2100	10.5	1.05

Table 3 gives operating frequency and how to find power density value.

TABLE III. REVISED EM FIELD EXPOSURE FOR MOBILE TOWERS

Frequency Range	Power density (W/m ²)
400MHz to 2000MHz (2 GHz)	f / 200
2GHz to 300GHz	10

The number of transmitting antennas is restricted by ICNIRP regulations. Table 4 provides details on minimum distance and transmitting antennas. The distance between the antennas of the base and home communication stations vary depending on the number of antennas installed on the MBS.

TABLE IV. ANTENNA STANDARD

Sr. No.	No. of transmitting antennas	Secure distance (in meters)
1	2	35
2	4	45
3	6	55

Due to modification by DoT, now the standard adopted by India is 10 times more stern than other countries. Initially India was following 4.5 w/m², but due to revision now it is 0.45 w/m² standard. Standards for EM field from MBS starts at 0.001 and ends at 6 w /m².

B. World health organization

Every nation establishes its own national standards for exposure to electromagnetic fields. Furthermore, the majority of national regulations are based on guidelines established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). This non-governmental organization, officially recognized by the World Health Organization, assesses global scientific implications. The ICNIRP generates guidelines that suggest exposure limits based on an evaluation of the literature. These guidelines are routinely examined and revised as needed.

C. ARPANSA

The Australian government receives recommendations on these exposure levels from the ARPANSA in order to ensure everyone's safety. In order to do this, ARPANSA created guidelines for limiting exposure to radiofrequency fields between 100 KHz and 300 GHz. It is founded on international regulations established by the World Health Organisation (WHO) and the International Commission for Non-Ionizing Radiation Protection (ICNIRP).

The Standard is supported on present technical investigation and global guidelines that show the intensity at which dangerous effects may occur and it sets boundary for telecommunications services and utensils well below these levels.

Depending upon the frequency range the EMF exposure standards will change and their impacts on the human body. Commonly the EMF exposure is measured in two ways that is near field and far field exposure; it is measured in the form of power density and electromagnetic field. The exposure range is from two to ten watts / square meter (W/m²) depending on the operating frequency. For 5G infrastructure, the public exposure limit is 10 W/m² [7].

D. CENELEC

Some European countries have already developed standard for their country and also written the rules to protect the society from electromagnetic fields. Some European international committees have created country wide standards or hints for the safety of the society from electromagnetic fields. To overcome from the problem of radiation from base stations there may be a one tier or two tier solutions and how to outline these two stages of protection. NRPB from Great Britain has given some rules which are helpful for all countries. Rules set by Germany's DIN / VDE Standard and Austria's OVE Standard differentiate between controlled / uncontrolled areas and workers/general public, respectively [2][6].

III. RESULTS AND DISCUSSION

A. Comparasion with standard reference levels

Most helpful policies and regulations have been developed by a variety of administrative, governmental, and organizational bodies to protect society from the potentially fatal

electromagnetic radiation that MBS transmits. These international organizations—ICNIRP, NCRP, NRPB, IEEE, FCC, and CENELEC—developed guidelines about electromagnetic field exposure from base communication stations for the public and workers [1-6]. China, Salzburg, Russia, Poland, Italy, Switzerland, and Austria has EM field threshold value is 0.1 W/m², which is much lesser than ICNIRP standard [1].

Various studies linked to EM field from MBS presents undesirable health issues of RF radiation, for example faintness, headaches, fatigue, sleep problems, irritability etc.

Therefore European nations are in worry to warm impacts because of EM radiation from MBS. Some EM field standards give more significance to various responsive places such as schools, hospitals etc.

Smart phone gives EM field only during active call however MBS originates EM radiation 24 hours uninterruptedly in all sides of zone. In India some construction / apartment / personal owners are giving permission to install antenna mast on top floor only for rental money. While installing a MBS in housing area mobile operators does not take permission of residents and govt. authorities. Therefore more systematic study on this area is required. The next segment gives the information of actual methodology of EM field from MBS [9].

For EM field, there are some reference standards set by universal associations, for example, ICNIRP, WHO, IEEE, FCC, and ARPSNA and so on. Table V shows worldwide standard for 900 MHz.

TABLE V. WORLDWIDE EM FIELD EXPOSURE FOR MOBILE BASE STATION TOWERS

Exposure limits for the general public for electromagnetic fields at 900 MHz in inhabited areas in European Union and outside the European Union (July 2017)			
Country	Electric field v/m	Magnetic field μT	Power density in W/ m ²
Austria	41	0.14	4.5
Belgium	21	--	--
Bulgaria	--	--	0.1
Australia	41	0.14	4.5
Italy	6	0.02	0.1
Czech Republic	41	0.14	4.5
France	41	0.14	4.5
Germany	41	0.14	4.5
USA	--	--	6

United Kingdom	41	0.14	4.5
India	13	0.041	0.45
Switzerland	--	--	6
Japan	48	0.16	6
Spain	41	0.14	4.5
China	12	0.04	0.4

The table V shows the Comparison of international policies on electromagnetic fields. From above table it is observed that Bulgaria and Italy are stricter for power density limits. In case of electric and magnetic field Belgium, Italy, China and india they have lower values of electric and magnetic fields [12]. The Department of Telecommunications (DoT) changed these reference levels and values for frequencies 900, 1800, and 2100 in September 2012. Modified DoT norms for exposure to EM fields are presented in Table 3.3 [10].

TABLE VI. REVISED EM FIELD RADIATION NORMS FOR MBS.

Frequency in MHz	Old ICNIRP standard (W/ m ²)	Revised DoT standard (W/ m ²)
900 MHz	4.5	0.45
1800 MHz	9	0.9
2100 MHz	10.5	1.05

Antenna exposure is also limited by the number of cellular antennas that can be mounted atop a cellular base station tower. The information about the number of antennas and the safe distance is provided in Table 3.4. The number of antennas installed on the base station tower determines the distance between the antennas and the residential area [11].

TABLE VII. SECURE DISTANCES FOR MULTIPLE ANTENNAS

Sr. No.	Transmitting antennas	Minimum Distance (in meters)
1	2	35
2	4	45
3	6	55

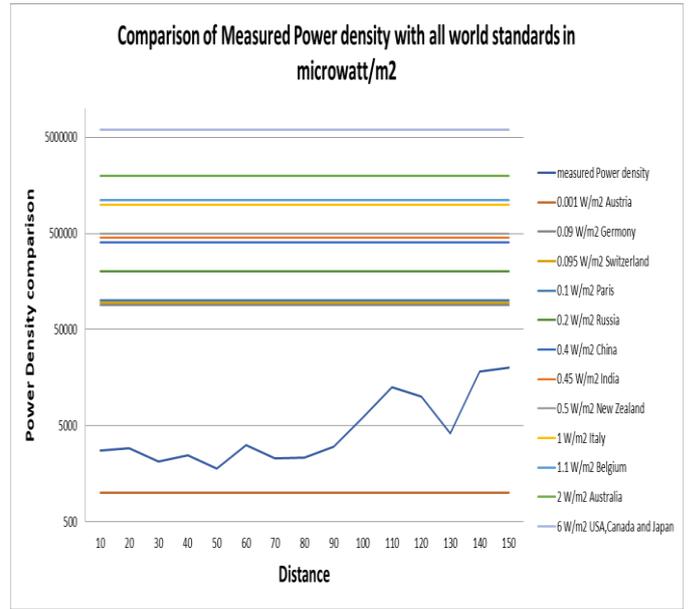


Fig. 1. Comparison of different EMF exposure standards

IV. CONCLUSION

Due to large number of increased subscribers of smart phone users, number of MBS are also increased net effect of this is that it increases EM field exposure rapidly near antenna mast. It is today’s need to create awareness in Indian society regarding this EM field exposure. That is what are different standards set by worldwide organizations, what are EM field exposure values set by ICNIRP and DoT.

After observing the table 4 that is comparison of different world standards of EMF exposure India is following the ICNIRP and DoT standard whose exposure level standard is 0.45 w/m². If we compare this value with other country standard then it is at moderate level.

Austria is very strict regarding EMF exposure its exposure level standard is 0.001 w/m² it is 450 times lesser than other countries. Followed by Austria the other stricter countries are Germany, Switzerland, Italy, Poland, Paris, Hungary, Russia and Bulgaria. Their EMF exposure levels are 0.09, 0.095, 0.1 and 0.2 respectively.

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