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Mobile Tower Radiation-An Assessment of Radiation Level and its Health Implications in the Residential Areas of Western Ghats in Idukki, Kerala

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Abstract

In this paper, the RF radiation power density near the cell towers in the residential areas of high ranges in Idukki district of Kerala has been measured. In addition, the study also explored if any relation exists between RF exposure and human health. During the course of this work, intensities of time varying electric, magnetic and electromagnetic fields have been measured and the areas have been categorised based on the distance from the nearest cell tower. Power levels are measured inside and outside the buildings for getting an inference on how the roof and wall materials block the RF radiations. A survey is conducted using personal interview method for identifying the health complaints of inhabitants. Statistical tests are carried out to find the relation between human health issues and RF exposure. Out of thirty two diseases analysed, only four were found to be directly related to radiation exposure. The study proposes a new Indian standard for RF exposure.

Keywords: RF exposure, cell tower radiation, exposure limits, radiation effects.

INTRODUCTION

The last two decades witnessed a magical revolution in the field of telecommunication as well as in data communication. The number of cell phones and cell towers are drastically increasing all over the world. The conspicuous developments in cell phone technology have made our life much more comfortable. Cell phone communicates in the range of radio frequency, which is a low frequency non-ionising radiation. A mobile phone base station is designed in such a way that the cell phones coming under its coverage area should be able to transmit and receive enough signal which enables proper communication within a few kilometres. In order to establish more coverage, most of the towers are mounted near populated areas. People living nearer to the towers receive much more signal level than required for most of the times. In India, lacks of people live in the high radiation zones. But most of the people are not concerned about the effects of radiations on health and possible safety measures to overcome the hazards. This demands the need for continuous studies on the effects of radiation on public health. The aim of the paper is to study the effects of RF radiation from cell towers on the health of nearby inhabitants.

Many scientists across the globe studied the harmful effects of mobile radiations on human health and living beings [1-6]. Conspicuous researches are being carried out on the health issues of inhabitants living near mobile base stations. Studies on RF radiation from mobile towers based on power density measurements in residential areas close to cell tower sites are done by Ioan Eustatiu and Claudiu [7]. Similar studies were done by Damiano Urbinello [8] and R.K Singh [9]. In many countries, the standards on exposure limits to non-ionizing HF radiation are based on ICNIRP guidelines [10]. Girish Kumar [11] studied the effects of RF radiations on inhabitants living 15m near cell tower. He concluded that, such people are exposed to 10,000 times stronger signal than required for mobile communication. Many other researches also concluded that the existing ICNIRP recommendations are inadequate for the safe living of humans [12-14]. The exposure limits in some countries like Russia is lower than the ICNIRP recommendations [15].

The study in this paper is to investigate the relationship between RF exposure and human health issues and to search whether any inadequacies exist in the current Indian standard of RF exposure. The remaining part of this paper is arranged in the following manner. Section II presents the materials and study. Section III describes the case study analysis. A discussion on the study result is made in section IV. Section V concludes the work.

MATERIALS AND METHODS

Health effects can be divided in to two categories; short term effects and long term effects. The short term effects include brain electrical activity, heart rate, blood pressure, etc. The long term effects include tinnitus, headaches, joint pain, memory loss, muscle problem, cancers, tumours, etc. In May 2011, International Agency for Research on Cancer (IARC) has classified RF as carcinogenic to human (Group 2B) [16]. International Commission on Non – Ionizing Radiation Protection (ICNIRP) has published guidelines [10] for limiting EMF exposure that will provide protection against known health problems. According to the guidelines, the effects can be classified into two; direct effects result from the direct interaction of field with the body and indirect effects involving interaction of objects with a different potential from the body. ICNIRP provides two classes of guidelines.

Basic Restrictions: These are restrictions on exposure to time varying electric, magnetic and electromagnetic fields. The physical quantities used to specify these restrictions are Current Density (J) , Specific Absorption Rate (SAR) , and Power Density (S).Among these only power density in air can be measured outside the body.

Reference levels: These are levels given for practical exposure assessment to determine whether the basic restrictions have been violated or not.

Coupling mechanisms between field and the body

As per the ICNIRP guidelines there are three basic coupling mechanisms by which electric and magnetic fields can directly interact with living matter (UNEP/WHO/IRPA 1993); they are, coupling to low-frequency electric fields, coupling to low-frequency magnetic fields and absorption of energy from electromagnetic fields.

Coupling of low frequency electric field

When the time varying electric field interacts with the human body, the interaction of electric field with the human body causes generation of electric current (flow of electric charge) and formation of electric dipole(polarization of bound charges). Various factors that constraints the amount of interaction are electric conductivity, permittivity of the body part, type of tissues and frequency of the field. Ohms law relates the current density and internal electric field as, $J = \sigma E$ (where, J is the current density, σ is the conductivity of the body part and E is the electric field intensity) [10]. The interaction depends on the size and shape of the body part, and the position of the body part in the electric field.

Coupling of low frequency magnetic field

Human body's interaction with the time varying magnetic field generates induced electric field and circulating electric current inside the body. The amount of the two parameters depends on the radius of the loop, electrical conductivity of the tissue and the rate of change of magnetic flux density.

Absorption of energy from electromagnetic field

Low frequencies below 100 kHz produce little absorption. But frequencies in the rage of UHF and Microwave result in higher degree of absorption and temperature rise. Above 10 GHz, the effect is only on the body surfaces. EM fields can be divided in to four ranges [10] according to the difference in absorption.

1) Frequencies between 100 kHz and 20 MHz, where significant absorption happens in the neck and the legs.
2) Frequencies between 20 MHz and 300 MHz, where higher absorption can occur in the whole body.
3) Frequencies between 300 MHz and 10 GHz, where significant local, non uniform absorption occurs.
4) Frequencies above 10 GHz which affect the body surfaces only.

Radiated power

Power density P_d at a distance R is given by,

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

Where, P_t = power transmitted, W.

G_t = gain of the transmitting antenna, V/V.

R= distance from antenna, m.

Methodology

The study was carried out at the residential areas of Western Ghats. The area includes four villages of Idukki district in Kerala. Our primary focus is on the exposure and health effects of the inhabitants living under the selected 14 cell towers. All the towers were installed within a period of 5 to 10 years. We divided the area under study into five different zones based on the distance from the nearest cell tower as follows.

Zone 1 - Distance less than 50 metres

Zone 2 - Distance within 50 – 100 m

Zone 3 - Distance within 100 – 200 m

Zone 4 - Distance within 200 – 300 m

Zone 5 - Distance above 300 m

We measured the intensities of time varying electric, magnetic fields and power density of EM field inside and outside the residential buildings. A survey was conducted using personal

interview method. So 229 persons under different age group and gender were considered and enquiry was made about 32 different diseases which were suspected to be caused by radiation. Our aim was to find out if any relation exists between radiation exposure and the diseases. Statistical tests including T – test, independent sample test, Levene's test for equality of variance and ANOVA were conducted to find out the result.

DEVICE USED

MECO's Electrosmog Meter Model 9720 was used to measure the readings. The device was a three axes meter able to measure E, H and power density under various scales. However, in this manuscript, we are dealing only with power density measurements. The device possesses a frequency Range of 50MHz to 3.5GHz. Non-directional (Isotropic) measurement is possible with the three channel measurement sensor. With this device, high dynamic range is possible due to the three channel digital results processing. The photograph of the device and its usage are shown in Figures 1 (a) and 1(b) respectively.

RESULTS AND DISCUSSIONS

In this study, our aim is to get an inference about the role of radiation exposure in 32 different diseases. As per our observation, only 4 diseases were found to have obvious relation to the cell tower radiation. They are, joint pain, sleep disorders, migraine related headaches and digestive problems. Following sections give a comprehensive analysis of how the diseases are related to the cell tower exposure.

(a) (b)

Figure 1: (a) Photograph of the MECO's Electrosmog Meter 9720 and (b) its usage.

Diseases and cell power radiation

Joint Pain

About 25 % of the people under the study are found to be affected by joint pain. Statistical tests reveals that the victims were living under an exposure level of Mean Power Density (MPD) 410.28 mW/m^2 with a Standard Deviation (SD) of 297.25. The zone wise percentages of victims are shown Table 1.

Table 1: The zone wise percentages of victims (joint pain).

Zone	Percentage of people affected
1	35
2	32
3	16
4	10
5	7

Next, when the affected people were classified gender wise, it has been found that, 58 % of them were from female and 42 % from male categories. Age group comparison is also made on the affected class and its result is shown in Figure 2.

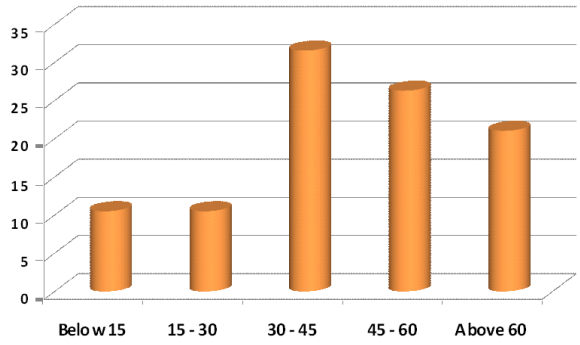

Figure 2: Age group comparison (joint pain).

Our study points out that 7.02 % would have been the social average for joint pain (from zone 5) if cell tower radiation was not there. Unfortunately now it is 25.11%. The study confirmed that 18.09 % increase in the case of joint pain is due to cell tower radiation as the victims were exposed to 410.28 mW/m^2 with a SD of 297.25.

Sleep disorders

In our study we found that 22.03% of people was found to be suffering from sleep disorders. We also noticed that, they were facing an exposure of MPD 454.386 mW/m^2 with a SD of 305.603. Table 2 shows the zone wise analysis.

Table 2: The zone wise percentages of victims (Sleep disorder)

Zone	Percentage of people affected
1	36
2	35.7
3	18
4	10
5	0.3

According to the analysis based on gender, 48 % of the affected were from female and 52 % from male categories. When different age groups are compared, it is clear that the group 30-45 is more affected as shown in Figure 3.

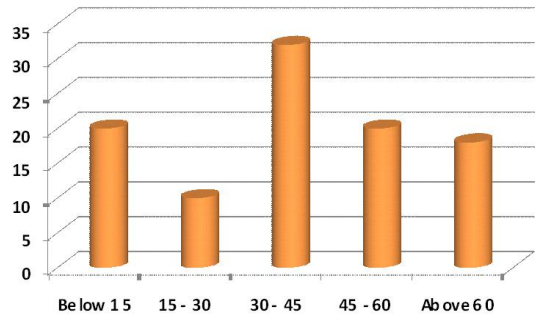

Figure 3: Age group comparison (sleep disorder).

An analysis on the victims of sleep disorders shows that 0.3 % would have been the social average in a safe radiation zone. But, now it is up to 22.3%. Our conclusion is that cell tower radiation is the cause for the 22 % increase in the case of sleep disorders. The affected people were facing an exposure of 454.386 mW/m^2 of mean value with a SD of 305.603.

Migraine related headaches

It has been found that about 23.9 % of the people under the study area are affected by migraine related headaches and they were exposed to MPD 289.989 mW/m^2 with a SD of 277.866. Table 3 summarises the percentage of people suffering from migraine related headaches living in different zones. In addition, 61 % of the affected are females and 39 % are males. The result of age group comparison is shown in Figure 4. It shows that middle aged class is more susceptible to migraine related headaches.

Table 3: The zone wise percentages of victims (Migraine related headaches)

Zone	Percentage of people affected
1	25
2	23.8
3	27.38
4	10.72
5	13.1

This study confirms that in a safe radiation zone, 13.1 % would have been the social average. However presently it is 37%. The study further indicates that a 23.9 % increase in the case of migraine related headache is due to the effects of cell tower radiation. The affected people were facing radiation exposure of 289.989 mW/m^2 of mean value with a SD of 277.866.

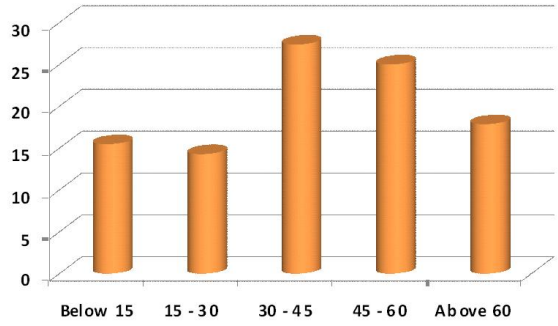

Figure 4: Age group comparison (migraine)

Digestion related problems

As per the results of our study, digestion related problems have been noticed in about 23.34% of the people. Radiation exposure of MPD 340.436 mW/m^2 with a SD of 273.812 is measured in their inhabitancy area. The zone wise percentages of victims are portrayed in Table 4.

Table 4: The zone wise percentages of victims (digestion related problems)

Zone	Percentage of people affected
1	28.3
2	22.64
3	26.42
4	18.87
5	3.77

If we classify the victims based on their gender, 53 % of them fall under female group and 47 % under male category. A comparison is also made on the affected based on their age group and its result is shown in Figure 5.

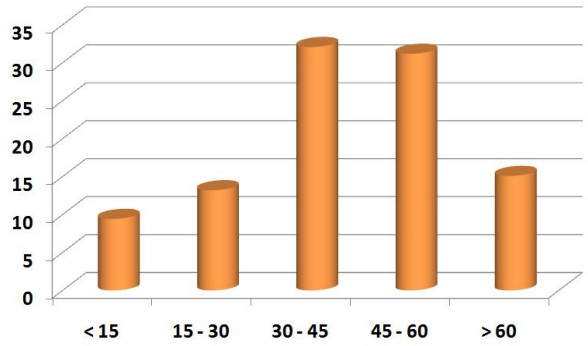

Figure 5: Age group comparison (digestion related problems).

The study on digestion related problems points out that 3.77 % is the social average in zone 5, where radiation effects are comparatively less. Unfortunately, now it is 23.34%. Thus we can conclude that, the 19.57 % increase found in the case of digestion related problems is due to the bad effects of cell tower radiation. In this case, the victims were exposed to 340.436 mW/m^2 of mean value with a SD of 273.812.

Male – Female comparison

Analysing the results of above observations, we can compare the impact of the four diseases on male-female categories. Figure 6 aggregates the result of this comparison. Based on the above comparison, it is clear that females are more prone to the bad effects of cell tower radiation.

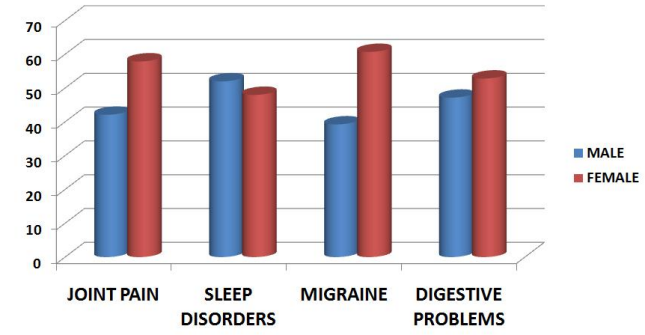

Figure 6: Gender wise comparison of the four diseases.

Diseases which are not correlated to radiation effects

A large number of studies on the effects of cell tower radiations confirm that diseases such as Alzheimer's, various categories of cancer, fertility issues etc are strongly related to mobile tower radiations. However, out of the 32 diseases we studied, only four of them are found to have a vital relation with radiation exposure. A discussion about the four diseases has already been made in the above sections. The result of this study gives an inference that the remaining 28 diseases which were examined have no conspicuous association with radiation exposure in the studied area. They are infertility, problems during pregnancy /affected fetus, skin diseases, tinnitus, cataract, uveal melanoma and other ophthalmic problems, bone weakness, gland tumours, breast cancer, bone cancer, cancer abdomen/stomach, liver cancer, throat cancer, blood cancer, spinal cord cancer, brain cancer, cancer other types, Alzheimer, Parkinson, motor neuron, heart diseases, cholesterol, blood pressure, varicose vain, tumours other types, ear problems other types and Liver problems other types.

People under different exposure limits

As a part of this work, we examined the exposure range in which the inhabitants were living within our survey area. It has been found that 18.86% of the inhabitants were facing an exposure greater than the current Indian slandered, 470mW/m^2. Figure 7 illustrates a chart which summarises the percentage of people facing different exposure limits.

How the Roofs and Walls prevent the Radiation?

Using the radiation meter, we analysed the power density inside and outside the residential buildings. By statistical means, we tried to find out how the different building materials preclude the radiation effects. The Tables 5 and 6 show the roof and wall comparison respectively. We observed that the material with lowest P_{in}/P_{out} value is the better choice. Where, P_{in} is the power density measured inside the building and P_{out} is the power density measured outside the building.

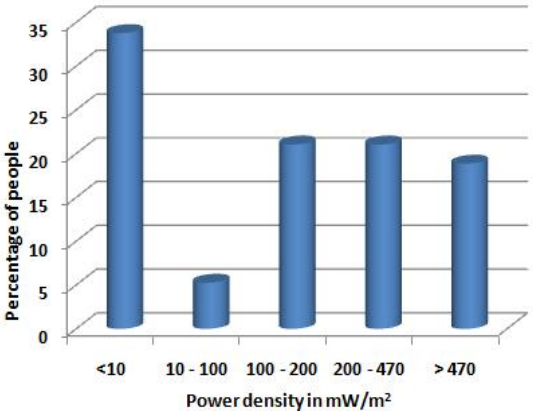

Figure 7: Percentage of peoples living under different exposure limits.

Table 5: Roof comparison

Roof material	Mean P_{out} (mW/m^2)	Mean P_{in} (mW/m^2)	P_{in} / P_{out}
Aluminium	280.550	1.050	0.0037
GI sheet	444.785	285.662	0.6422
Asbestoses	220.700	197.312	0.7580
Glass and fibre glass	8.300	8.300	1.0000
Grass	328.448	246.939	0.7510
Concrete	175.256	133.355	0.7610

From Table 5, we can make an inference that, aluminium is a better choice for roof material and Table 6 confirms that fibre sheets are better as a wall material to reduce radiation effects.

Table 6: Wall comparison.

Wall material	Mean P_{out} (mW/m^2)	Mean P_{in} (mW/m^2)	P_{in} / P_{out}
Natural bricks	352.683	142.178	0.4031
Fibre sheets	187.132	11.436	0.0611
Cement blocks	227.307	189.789	0.8349
Grass	512.800	87.800	0.1127
Concrete	116.000	110.000	0.9480

Proposed standard

India adopted a safe radiation level of power density 470 mW/m^2. It is actually 1/10th of the ICNIRP suggestion. Unfortunately, our study shows that the current Indian standard is not safe; because the MPD value of above mentioned four diseases were well below the current Indian standard value. Figure 8 shows the comparison between the current Indian slandered and the MPDs of the four diseases.

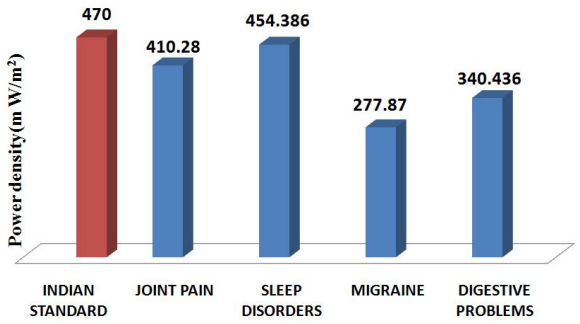

Figure 8: Comparison between the current Indian standard and the MPDs of the four diseases.

The above comparison proposes that the current Indian standard value of power density 470 mW/m^2 should be lowered to 200 mW/m^2 at least, for the best assurance of safety. Using this value now we can calculate the new safe limit for the transmitting antenna power.

Power density P_d at a distance R is given by,

$$P_d = \left(\frac{P_t \times G_t}{4\pi R^2} \right) \qquad (1)$$

According to the current Indian standard,

P_t = 20W.

P_d = 470 mW/m^2

Therefore (1) becomes,

$$0.47 = \left(\frac{20 \times G_t}{4\pi R^2} \right) \qquad (2)$$

According to our suggestion, P_d = 200 mW/m^2.

Thus (1) becomes,

$$0.2 = \left(\frac{P_t \times G_t}{4\pi R^2} \right) \qquad (3)$$

Solving (2) and (3), the new value for P_t is =8.51 W.

That is the transmitting power limit of the antenna should reduce to 8.51 W.

Another commonly used term is effective radiated power (ERP), and is defined as the product of P_t and G_t. Here, P_t = 20 W and G_t = 17 dB = 50. That is, ERP = 1000. Applying our proposed value of P_t (that is, 8.51 W), the new value of ERP is 425.5.

CONCLUSION

The RF radiation power density near the cell towers in the residential areas of high ranges in Idukki district of Kerala has been examined. It is found that 18.86% of the inhabitants in our study area were facing an exposure which exceeds the current Indian standard of power density 470 mW/m^2. Out of the 32 diseases analysed, only four (joint pain, sleep disorders, migraine related headaches and digestive problems) are found to have a close relationship with cell tower exposure. Our inference is that females are more prone to the hazards of RF exposure. Also, it is noticeable that middle aged persons are the victims of cell tower radiations. If we compare different building materials, aluminium is best suited for roofing and fibre sheet is the most successful among wall materials. Based on our studies, we can conclude that the current Indian standard for cell tower exposure is inadequate for the safe

living. Therefore, we propose a new standard for power density (200 mW/m^2), transmitting antenna power (8.51 W) and ERP (425.5). The ERP may not be limited to a single carrier. It should be fixed for the whole tower (for multiple carriers and multiple operators). At least 300 meter distance should be there between two cell towers. It is better to avoid staying within 300 meters of the cell tower. If unavoidable, use an extra layer of aluminium sheet to the roof and fibre sheet to the wall for proper shielding. Our observation area in this research was limited to a single district in Kerala. Further studies are required for drawing a more definitive conclusion.

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