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RF Radiation From Mobile Phone Tower And Their Possible Effects On Non Specific Health Symptoms

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Abstract: *In the present paper, we presented the study of complaints on thirteen (13) different health symptoms faced by inhabitants living near mobile tower – Global System for Mobile Communication (GSM 900 & 1800) and those inhabitants living in the area where there is no mobile tower. The study was conducted in three different localities in Aizawl city in the year 2024-2025. Questionnaires were conducted in all the localities. Power densities were measured in different places in all the localities. Health complaints between the localities were compared with that of the locality where there is no mobile tower. It was found that power density is much higher in the area where there is mobile tower than the area where there is no mobile tower. Questionnaire responses from all the localities were statistically analysed and compared by performing paired sample T-test. Out of the thirteen (13) different symptoms studied it was found that the comparisons are statistically significant with $p < 0.05$ in eight symptoms. It was found that there was strong positive correlation between power density and health complaints with R^2 value 0.905.*
Key words: *Health symptoms, power density, RF radiation.*

INTRODUCTION:

Cellular wireless communication has become necessarily important. Wireless technology is based on extensive networks of base stations that connect the users through Radio Frequency (RF) signals. There has been an unprecedented growth of mobile industry in India during the last two decades. This has led to a great deal of concern about possible health consequences caused by human exposure to RF in general and radiations from base stations in particular [1],[2],[3].

RFR is the flow of photons with energy levels that classify radiation as ionizing or non-ionizing. Mobile communication typically employs non-ionizing frequencies between 800 MHz and 3 GHz, while base stations operate primarily at 900 and 1800 MHz within the microwave spectrum (300 MHz–300 GHz). Although non-ionizing radiation lacks the energy to ionize atoms, concerns persist regarding possible biological effects.

It is believed that mobile phones produce RF energy of non-ionizing radiation which is too low to heat the body's tissues, and hence is unlikely to have the same impact on human health as those produced by ionizing radiations such as X-rays [4]. Nonetheless, there is still a need to determine the level of health risks caused by RF radiations. With the significant increase in mobile phone usage, possible health risks related to RF exposure have become the subject of considerable attention [6], [7]. This includes effect from exposure to both cell phones and base stations.

Health concerns can be divided into two main categories : short term and long term effects. The short term effect includes brain electrical activity, cognitive function, sleep, heart rate and blood pressure [8]. However, the long term effects includes tinnitus, headache, dizziness, fatigue, sensations of warmth, dysesthesia of the scalp, visual symptoms, memory loss and sleep disturbance, muscle problem and epidemiological effects including cancer and brain tumours[9],[10].

Zothansiama, et al. [15] of India, in 2017, evaluated effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters). The study found higher RF radiation exposures and statistically significant differences in the blood of people living closer to the cellular antennas. The group living closer to the antennas had for example, statistically significant higher frequency of micronuclei and a rise in lipid per oxidation in their blood. These changes are considered biomarkers predictive of cancer.

To regulate exposure, international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) have established guidelines. Occupational limits are higher than public limits due to controlled environments. ICNIRP and EU recommendations (1998) recommended maximum exposure at 4.7 W/m^2 for GSM 900 and 9.2 W/m^2 for GSM 1800, while the Bio-Initiative Report (2012) recommends 0.5 mW/m^2 [11], [12], Salzburg resolution 2000 (1 mW/m^2), EU (STOA) 2001 (0.1mW/m^2) [13], the current Indian Standard (450 mW/m^2) [14].

METHODOLOGY:

(i) Measurement of Power Density and Frequency Spectrum -

At each of the selected sites (in Aizawl city of Mizoram 23.7307° N, 92.7173° E), an initial investigation was conducted using a broadband RF exposure meter measuring the power density. For this purpose, a spectrum analyzer, HF-60105V4, manufactured by Aaronia, Germany was used. The instrument is a High Frequency spectrum analyzer capable of measuring 1 MHz to 9.4 GHz with display available in dBm, V/m, A/m, W/m^2. The power density P_d of the RF energy is given by

$$P_d = \frac{nP_tG}{4\pi D^2}$$

Where n = Number of transmitters, P_t = Maximum power from each transmitter, G = Antenna gain (in decibel), D = Distance of the site from the transmitter.

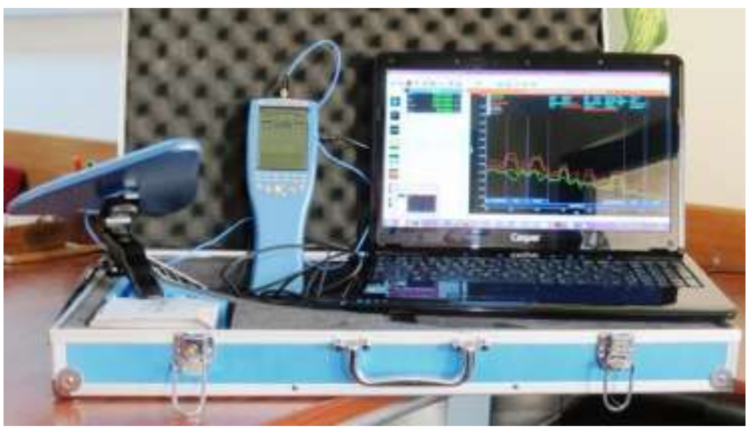

Fig. HF- 60105V4, Spectrum Analyser.

(ii) SAR value calculation -

SAR, a measure of the rate of energy absorption from an electromagnetic radiation into biological tissues is given by the formula

$$SAR = \frac{\sigma E^2}{\rho}$$

Where σ is the mean electrical conductivity of the tissues, ρ is mass density of the tissue, E is the electric field at the measured (exposed) site. It gives the amount of power in watt (rate of absorption of energy of electromagnetic radiation) absorb by 1 Kg of biological tissue.

To calculate electric field E, the following formula will be used

$$P_d = \frac{E^2}{Zo} = \frac{E^2}{120\pi} = \frac{E^2}{377}$$

i.e. $E = \sqrt{377 P_d}$

Where *Zo* is an intrinsic impedance. By measuring power density at each location, the corresponding electric field can be calculated, and hence the corresponding SAR value can be calculated.

(iii) Statistical Analysis of Questionnaire on Non Specific Health Symptoms

Statistical analysis was be performed using SPSS version 27 to investigate whether there is statistically significant health complaints and correlation between the power densities and the health complaints. The purpose of this study would be to investigate whether there is any correlation between the power densities, SAR values and the health complaints by inhabitants living near cell tower and those living within the locality where there had been no cell tower where power density is very low (net average value for GSM 900 and GSM 1800 is 0.004 mW/m^2). If there is a positive correlation, it may be possible to conclude that higher power density causes more health complaints. The format of questionnaire used for the study was as per the format developed for the study on mobile phone users by Santini *et al.* 2002 [16].

Table 1: Details of the different levels of health complaints.

Level	Indication	Frequency of complaints
0	Never	-
1	Sometimes	Once a week
2	Often	2 or 3 times a week
3	Very often	More than 3 times a week

RESULTS AND DISCUSSION

(i) Measurement of Power Density and (ii) SAR value calculation -

The study was conducted in four different localities in Aizawl city viz. Nursery Tlawng Road (NT, 23°42'58.76"N, 92°42'25.22"E), Chaltlang Mual veng (CV, 23°45'05.78"N, 92°43'25.00"E), Electric veng (23°44'11.73"N, 92°43'05.70"E) and Thuampui (23°44'39.36"N, 92°44'15.79"E). A total of 128 power density measurements were done at 64 different locations (64 measurements each for GSM 900 and GSM 1800).

Power density measurements were done first in one location where there is no mobile tower called NT at the coordinates 23°42'58.76"N, 92°42'25.22"E at 16 different places. The measurements were done for both GSM 900 and GSM 1800. The net average power density was 0.004 mW/m^2. The questionnaire responses on health complaints were taken as the reference i.e. control group. The same measurements were done for other three localities in Aizawl which were selected at random where there were mobile towers. In one locality called CV at coordinates 23°45'05.78"N, 92°43'25.00"E the net average power density was 6.15 mW/m^2 with SAR value of 0.001W/Kg for GSM 900 and 0.003W/Kg for GSM 1800. In the other locality called EV at coordinates 23°44'11.73"N, 92°43'05.70"E the net average power density was 8.85 mW/m^2 with SAR value of 0.002W/Kg for GSM 900 and 0.003W/Kg for GSM 1800. In TP locality at 23°44'39.36"N, 92°44'15.79"E the net average power density was 0.8 mW/m^2 with negligible value of SAR. All the power density measurements and the corresponding SAR values are well below the current Indian national limit and the ICNIRP and IEEE standard. However, the measured power densities in three localities – CV, EV, TP are above the maximum limit suggested by Bio-initiative Report 2012 and Salzsburg Resolution 2001.

Power density measurements were analyzed based on distance – within 50 m and outside 50 m from the mobile towers in three localities – CV, EV and TP. It was observed that in CV and EV power densities were higher within 50 m distance and lower outside 50 m. In TP, the reverse was observed (given in table 3, 4, 5). Although power density is inversely proportional to the square of the distance from the tower, geometrical factors play crucial role in the value at the measured sites. The measured sites may be nearer to the tower, the presence of different constructions and the topography can block the radiation coming from the tower. The other factor which can be responsible for the lower value of power density within 50 m radius is that the primary beam from the tower may passed away not directly incident on the measured site.

Power density measurements in different localities given below in the following tables :

Table – 2 : Power density measurement and Calculation of SAR value at Nursery Tlawng Road (NT)

	GSM 900 (a)	**GSM 1800 (b)**
No. of measurements	16	16
Average power density	0.002 mW/m^2	0.007 mW/m^2

Average Electric field	0.027 V/m	0.051 V/m
Average SAR value	0.000 W/Kg	0.000 W/Kg
Net average power density	0.004 mW/m^2	
Net Average Electric field	0.039 V/m	

Table -3 : Power density measurement and Calculation of SAR value at Chaltlang Mual veng (CV)

	GSM 900	**GSM 1800**
No. of measurements	12	12
Average power density (PD)	3.64 mW/m^2 (a)	8.67 mW/m^2 (b)
Average PD for < 50m	6.87 mW/m^2 (c)	8.42 mW/m^2 (d)
Average PD for > 50m	0.41 mW/m^2 (e)	8.93 mW/m^2 (f)
Average PD for < 50m for (c) & (d)	7.64 mW/m^2	
Average PD for > 50m for (e) & (f)	4.67 mW/m^2	
Net average power density for (a) & (b)	6.15 mW/m^2	
Average Electric field	1.171 V/m	1.808 V/m
Average SAR value	0.001 W/Kg	0.003 W/Kg

Table -4 : Power density measurement and Calculation of SAR value at Electric veng (EV)

	GSM 900	**GSM 1800**
No. of measurements	20	20
Average power density (PD)	7.32 mW/m^2 (a)	10.38 mW/m^2 (b)
Average PD for < 50m	10.07 mW/m^2 (c)	19.96 mW/m^2 (d)
Average PD for > 50m	4.58 mW/m^2 (e)	0.81 mW/m^2 (f)
Average PD for < 50m for (c) & (d)	15.01 mW/m^2	
Average PD for > 50m for (e) & (f)	2.69 mW/m^2	
Net average power density for (a) & (b)	8.85 mW/m^2	
Average Electric field	1.661 V/m	1.978 V/m
Average SAR value	0.002 W/Kg	0.003 W/Kg

Table -5 : Power density measurement and Calculation of SAR value at Thuampui (TP)

	GSM 900	**GSM 1800**
No. of measurements	16	16
Average power density (PD)	0.27 mW/m^2(a)	1.33 mW/m^2(b)
Average PD for < 50m	0.19 mW/m^2 (c)	1.17 mW/m^2(d)
Average PD for > 50m	0.35 mW/m^2(e)	1.47 mW/m^2(f)
Average PD for < 50m for (c) & (d)	0.708 mW/m^2	
Average PD for > 50m for (e) & (f)	0.91 mW/m^2	
Net average power density (a) & (b)	0.8 mW/m^2	
Average Electric field	0.319 V/m	0.708 V/m
Average SAR value	0.000 W/Kg	0.000 W/Kg

(iii) Statistical Analysis of Questionnaire on Non Specific Health Symptoms

Questionnaire surveys on health complaints on thirteen (13) non specific health symptoms were conducted on each of the localities. The questionnaire was similar to the same used by Santini *et al.* (2002). Questionnaire was surveyed first in Nursery Tlawng Road (NT) locality, 22 female and 22 males, a total of 44 adult persons (18 – 60 years of age) participated in the survey. Accordingly, in all other three localities viz. Chaltlang Mual Veng (CV), Electric Veng (EV), Thuampui (TP), 44 persons (22 females and 22 males) each participated for the survey. In all the four localities the participants were selected such that they were non alcoholic, non smoker having no chronic diseases. The questionnaire responses were classified into four (4) different scales : 0 = never, 1 = sometimes, 2 = often, 3 = very often. The responses of questionnaire were analysed by using paired sample T test SPSS version 27.0. Being positive responses, scales 2 and 3 are considered for the statistical analyses. The details of questionnaire and their analyses are given in the following section.

Questionnaire responses from each locality was analyzed and compared based on three categories – [i] Responses from NT vs responses from each of the three localities i.e. NT vs CV, NT vs EV, NT vs TP [ii] Responses from male vs responses from female from each of the three localities. [iii] Responses from those inhabitants within 50 m from the tower vs responses from those inhabitants outside 50 m. Test for Statistical significance of the responses were done with Paired sample T test with 95% Confidence Interval (i.e. $p < 0.05$). Only those comparisons where $p < 0.05$ were considered statistically significant.

[i] When NT vs CV comparison was done, it was observed that out of the thirteen symptoms studied, responses from CV were statistically significant in five (5) different symptoms in scale 2, and non in scale 3. The statistically significant symptoms in scale 2 are : Sleep disruption (p = 0.033), Headache (p = 0.03), Cramp (0.015), Memory loss (p = 0.025), Dizziness (p = 0.002). For NT vs EV comparison it was observed that eight (8) symptoms in scale 2 and seven (7) symptoms in scale 3 were statistically significant showing the health complaints by those inhabitants in EV are more than that of NT. The statistically significant symptoms in scale 2 are : Fatigue (p = 0.033), Sleep disruption (p = 0.001), Headache (p = 0.000), Cramp (p = 0.035), Skin problem (p = 0.004), Visual disruption (p = 0.000), Dizziness (p = 0.002), Muscle pain (p = 0.000). In scale 3 the following symptoms were statistically significant : Fatigue (p = 0.001), Sleep disruption (p = 0.025), Headache (p = 0.008), Cramp (p = 0.033), Difficulty in concentration (p = 0.001), Memory loss (p = 0.025), Dizziness (p = 0.000), Muscle pain (p = 0.016). For NT vs TP no symptom is significant. In CV and EV, power densities were relatively higher than that in TP which is reflected in the number of significant health complaints.

Table – 6 : Compariso between NT vs CV, NT vs EV and NT vs TP. # mark indicates significant health symptoms –

[ii] For comparison between male and female from each locality of NT, EV, TP, a total of only three symptoms were significant. For NT locality only one symptom is significant in scale 2 – Cramp (p = 0.003) which is in favour of male and none in scale 3. For EV locality, significant symptom is observed in Fatigue (p = 0.025) in favour of female in scale 2 and Headache (p = 0.004) in favour of male in scale 3.

Table – 7 : Comparison between male (M) and female (F) from each locality on scales 2 and 3. # mark indicates significant health symptoms –

Sl. No.	Symptoms	Chaltlang Mual Veng (CV) [23°45'05.78"N, 92°43'25.00"E]				Electric Veng (EV) [23°44'11.73"N, 92°43'05.70"E]				Thuampui (TP) [23°44'39.36"N, 92°44'15.79"E]			
		Scale 2		Scale 3		Scale 2		Scale 3		Scale 2		Scale 3	
		M	F	M	F	M	F	M	F	M	F	M	F
1.	Fatigue						#						
2.	Nausea												
3.	Sleep disruption												
4.	Feeling of discomfort												
5.	Headache							#					
6.	Cramp	#											
7.	Difficulty in												
8.	Memory loss												
9.	Skin problem												
10.	Visual disruption												
11.	Hearing problem												
12.	Dizziness												
13.	Muscle pain												

[iii] For comparison between responses from within and outside 50 m, in CV two (2) symptoms were significant in favour of within 50 m, i.e. those inhabitants within 50 m are having more health complaints which is statistically more significant. The symptoms are : Headache (0 = 0.004) and Cramp (0.008) both in scale 2 and no symptoms were significant in scale 3. In EV, five (5) symptoms are significant again in favour of those inhabitants within 50 m in scale 2. The symptoms are : Fatigue (0.001), Sleep disruption (0.033), Headache (0.001), Visual disruption (0.035), Muscle pain (0.001). In TP locality no symptoms is found to be statistically significant.

Sl. No.	Symptoms	Scale 2				Scale 3			
		NT	CV	EV	TP	NT	CV	EV	TP
1.	Fatigue			#				#	
2.	Nausea								
3.	Sleep disruption		#	#				#	
4.	Feeling of discomfort								
5.	Headache		#	#				#	
6.	Cramp		#	#				#	
7.	Difficulty in concentration							#	
8.	Memory loss		#					#	
9.	Skin problem			#					
10.	Visual disruption			#					
11.	Hearing problem								
12.	Dizziness		#	#				#	
13.	Muscle pain			#			#	#	

Table – 8 : Questionnaire responses from each locality based on distance – less than 50m vs more than 50m on scales 2 and 3. # mark indicates significant health symptoms –

Sl. N o.	Sympto ms	Chaltlang Mual Veng (CV) [23°45'05.78"N, 92°43'25.00"E]	Electric Veng (EV) [23°44'11.73"N, 92°43'05.70"E]	Thuampui (TP) [23°44'39.36"N, 92°44'15.79"E]

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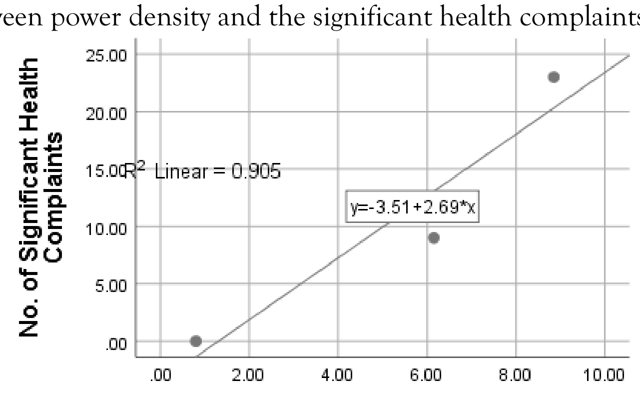
		Scale 2		Scale 3		Scale 2		Scale 3		Scale 2		Scale 3	
		<50	>50	<50	>50	<50	>50	<50	>50	<50	>50	<50	>50
1.	Fatigue					#							
2.	Nausea												
3.	Sleep disruption					#							
4.	Discomfort												
5.	Headache	#				#		#					
6.	Cramp	#											
7.	Difficulty in concentration												
8.	Memory loss												
9.	Skin problem												
10.	Visual disruption					#							
11.	Hearing problem												
12.	Dizziness												
13.	Muscle pain					#							

The average power density vs the total number of significant health complaints (both scales 2 and 3 added) is given below in table – 8 :

Locality	Ave. Power density	No. of significant health complaints (n)
CV	6.15 mW/m^2	9
EV	8.85 mW/m^2	23
TP	0.8 mW/m^2	0

The corresponding correlation graph is plotted giving R^2 value of 0.905 which shows that there is strong positive correlation between power density and the significant health complaints.



CONCLUSION

It has been observed that all the measured values of power density in all the localities were lower than the safety limit recommendation of ICNIRP and the department of Telecommunications, Govt. of India. However, in the localities CV and EV the average values of the measured power densities were higher than the recommendations of Bioinitiative report 2012. Although the measured power densities were very low compares to the recommendations of ICNIRP and the current Indian standard, it has been observed that many inhabitants were still having complaints on the nonspecific health symptoms which could be the case for further study.

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