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The Specific Absorption Rate (SAR) Of Cell Phone Radiations

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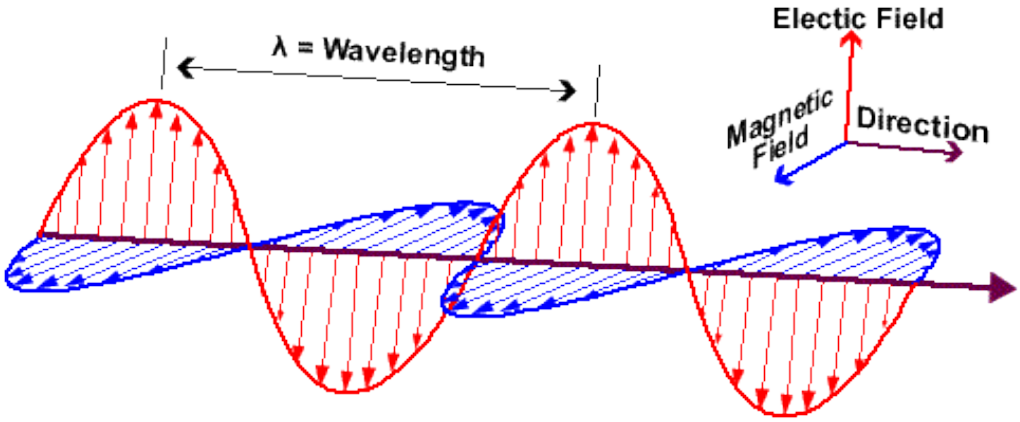
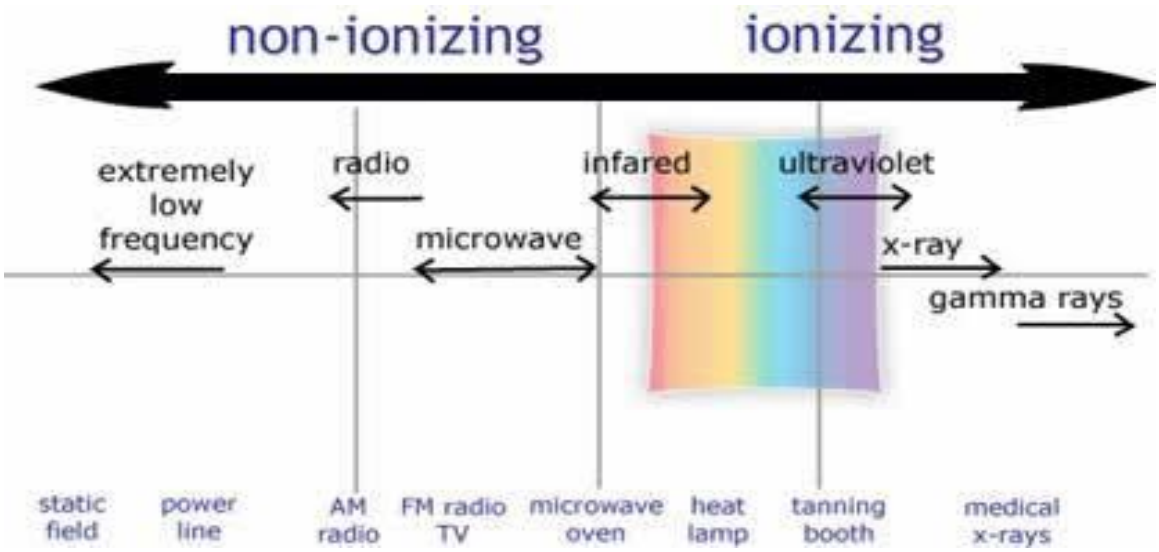
Introduction:

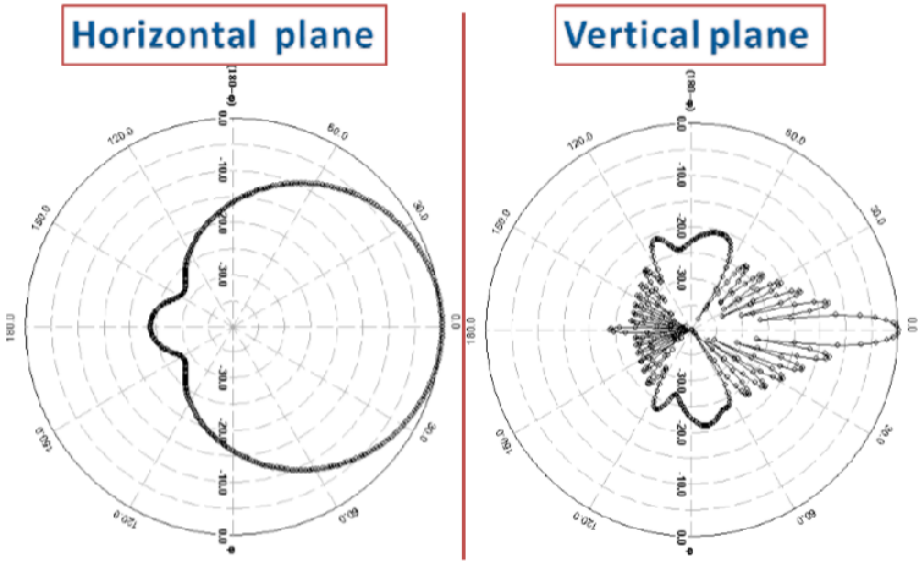
Nowadays, mobile cellular towers spread in corners of the globe and people in the world use cellular phones as a communication device every day. The population on earth live in both natural and man-made radiation world and in this research, the focus is on radiation of radio frequencies of base station towers on human health and this could be decreased in real world. Radiation itself is the energy that comes from a source and travels through space and may be able to penetrate various materials [1]. Radiation broadly is categorized into two parts, firstly, Ionizing radiation that have enough energy to cause ionization Occurs from the addition or removal of electrons from neutral atoms that can change the chemical reactions in the body and leads to damage in biological tissues including DNA such as Gamma Rays and X-Rays. The second type is Non-ionizing Radiation that does not have enough energy to cause ionization in human body and it only causes heating effect on body and does not have long-term damage on human tissues such as radar, radio frequency from cell phones. Electromagnetic radiation is a type of energy that all around us and takes many forms such as radio waves, microwaves, X-Rays and Gamma Rays.etc. and electromagnetic waves are composed of Magnetic Field and Electric Field which are perpendicular to each other [2].



The international scientific committee ICNIRP (International Commission on Non-Ionizing Radiation Protection) has set guidelines for human exposure to EMF. The guidelines include a substantial safety margin to assure that no adverse health effects are experienced when EMF levels are within the established limits [3] because, for example, in homes with highest exposures, people reported more horrible symptoms including: (a) three times as many headaches, (b) 2.3 times the incidence of tremor, (c) 2.5 times the incidence of cold hands/feet and concentration problems, (d) 2.4 times the incidence of appetite loss,(e) twice as much exhaustion and (f) twice as much fatigue. Mild et al. [4] discovered that among people living closer than 300m away from the BS, there was an increased incidence of headache. Chou et al. [5] claimed to have evidence of altered nerve function in the skin of a mobile phone user, around the ear area.



Radiation Pattern of Antenna



Specific Absorption Rate (SAR) :

A SAR value is a measure of the maximum energy absorbed by a unit of mass of exposed tissue of a person using a mobile phone, over a given time or more simply the power absorbed per unit mass. SAR values are usually expressed in units of watts per kilogram (W/kg) in either 1g or 10g of tissue.
Every country has a regulatory threshold value of SAR for mobile phone devices. In india the regulatory unit being **1.6 W/kg**.

In case of moto E the Head SAR is **1.50 W/kg** and body worn SAR is **1.36 W/kg**. (One can check this by type *#07# in one's phone)

For iPhone RF Exposure information

The highest SAR values are as follows:

1.6 W/kg (over 1 g) SAR Limit

Head: 1.13

Body: 1.16

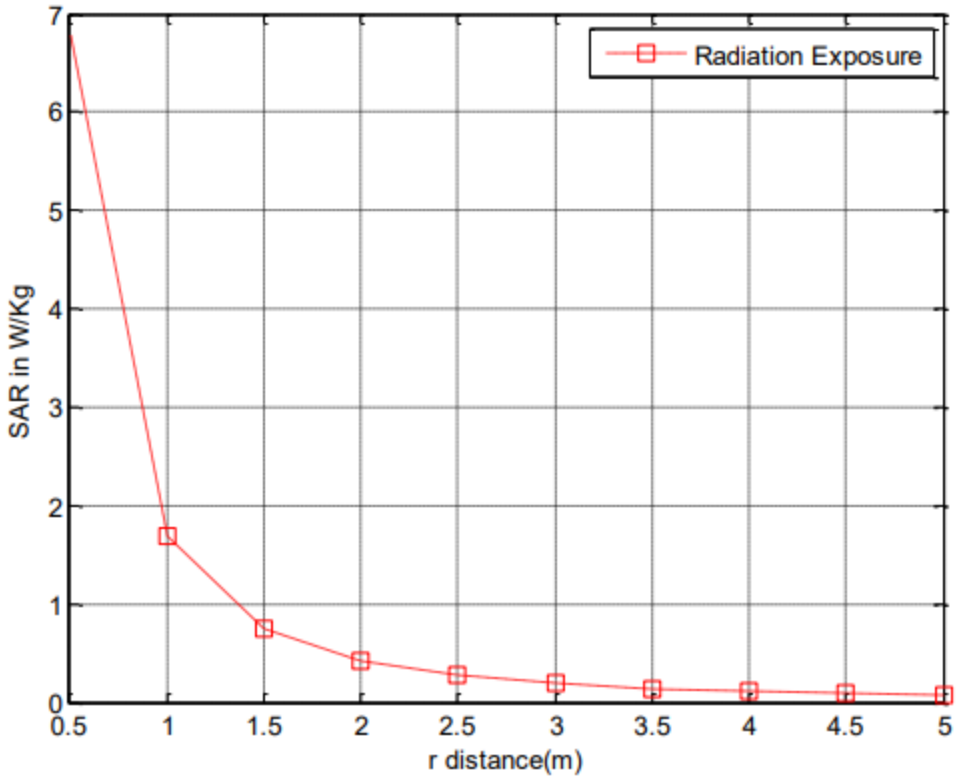
2.0 W/kg (over 10 g) SAR Limit

Head: 0.99

Body: 0.99

Cell phones and other mobile devices emit radiofrequency (RF) waves, a type of non-ionizing electromagnetic radiation (commonly called “cell phone radiation”). When you hold or carry a mobile device close to your head and body, you can absorb over half of the transmitted RF energy.

Cell phone radiation level varies from device to device and is measured by the Specific Absorption Rate (SAR). A mobile device’s SAR rating is used to estimate the maximum rate of RF energy absorption by a user’s head and body when using the device [6].



Manufacturer	Model	SAR Output (W/Kg)
Motorola	V195	1.6
Motorola	Rival	1.59
Sony Ericsson	Satio (Idou)	1.56
BlackBerry	Curve 8330	1.54
Nokia	E71x & X6	1.53
LG	Rumor	1.51
BlackBerry	Bold	1.51
Samsung	S3650 Corby	0.75
Samsung	SGH-G800	0.23
Samsung	Blue Earth	0.196
SAR is expressed in Watts per Kilogram Current UK Standard = 1.0W/Kg Current US Standard = 1.6W/Kg		

SAR Can be measured by electric field and temperature rise

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

E= Induced Field in Tissue (V/m)

σ= Tissue Electric Conductivity (S/m)

p=Tissue Conductivity (Kg/m^3)

SAR=4186 c ΔT/t

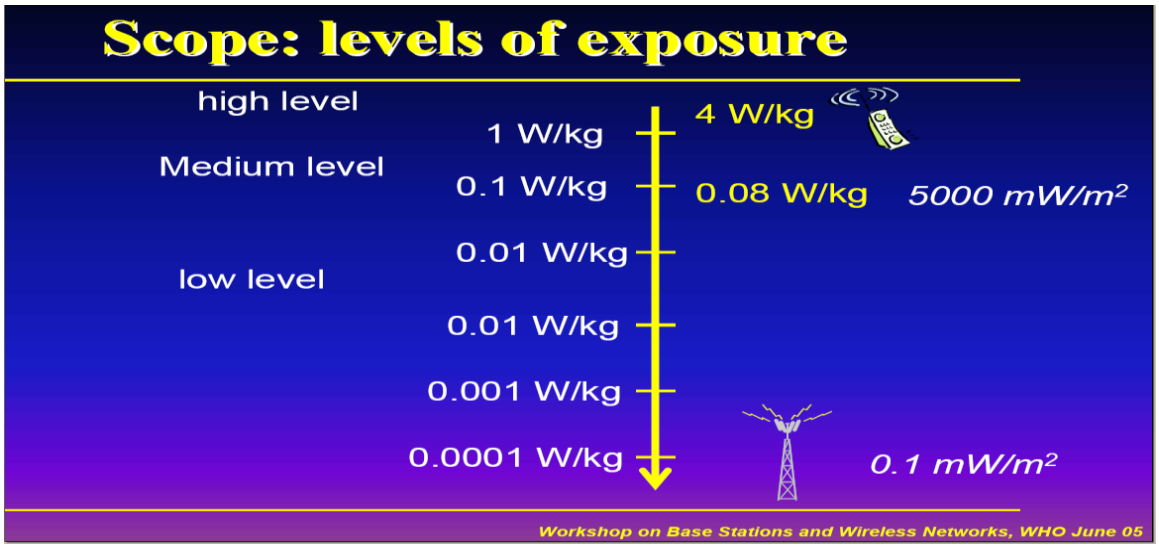
C= specific heat (kcal/kg.C)

ΔT= temperature rise

t=exposure time (sec.)

SAR can be determined by E Field or temperature measurement

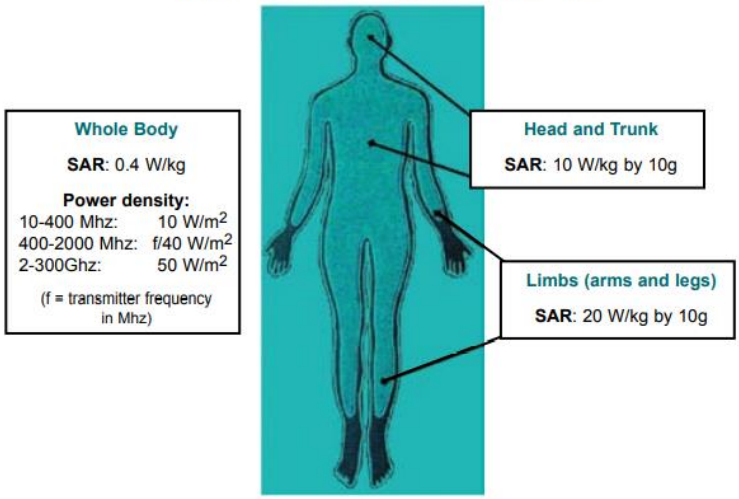
Level of Power density and SAR values measure by WHO showing low, medium and high level of exposure W/Kg

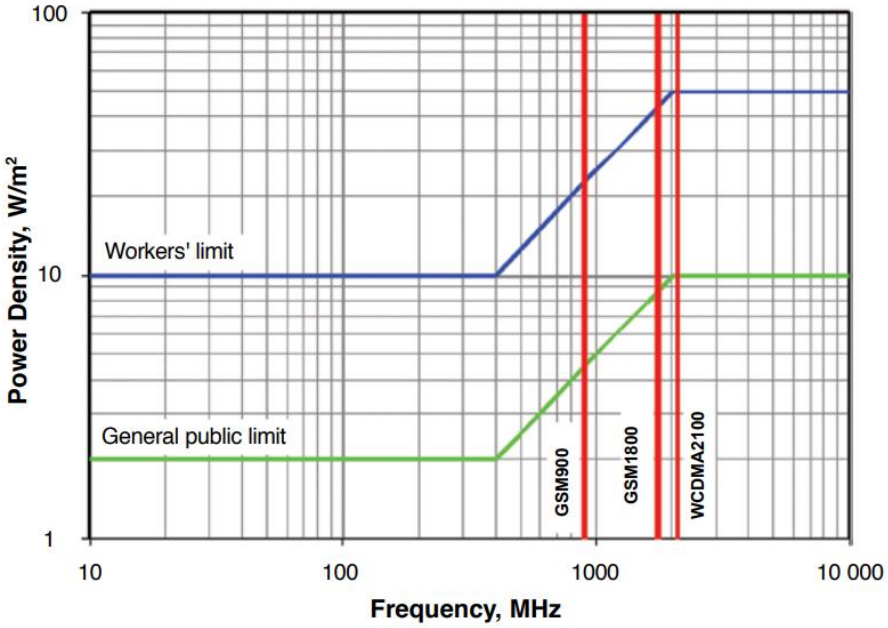


EMF limits for workers and the general public:

Most countries have adopted the limits developed by ICNIRP which include safety margins designed to assure protection for EMF workers and the general public. The level of absorption is expressed as SAR (Specific Absorption Rate) with the unit W/kg (watts/ kilogram of body tissue). Exposure guideline limits for EMF workers are higher than for the general public because workers are adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. Sufficient information or warning signs should be provided to ensure that other workers who have not received specific EMF training can take measures to avoid exposure above the relevant limit. Anyone who is not at work would be regarded as a member of the public and the public exposure guideline limits apply. In the frequency range from 10 MHz to 10 GHz, the EMF limits are expressed as SAR values, see 3.1.1 below. For practical assessments, e.g., using the field monitors described in section 3.5, ICNIRP also specifies frequency dependent reference levels, expressed as power density (S), electric field strength (E) and magnetic field strength (H). The reference levels can be used to show compliance with SAR limits but exceeding the reference levels does not necessarily mean that the SAR limits are exceeded. Reference levels for power density [7],[8].

ICNIRP Exposure Limits for Workers





SAR limits	ICNIRP limits		
Exposure Characteristics	Whole Body Averaged SAR	Local SAR Averaged over 10 g of tissue	
Workers' exposure limits	0.4 W/kg	10 W/kg	20 W/kg
General Public exposure limits	0.08 W/kg	2 W/kg	4 W/kg

[8] Figure

Compliance distance and Compliance Boundary:

In principle, RF levels decrease rapidly when a person moves further away from the source, e.g., a transmitting antenna. For each antenna, the RF level can be calculated based on its electrical characteristics or measured. The distance at which the RF level is always below the RF limit is called the compliance distance. The compliance distance may be based on the reference levels or an SAR evaluation, in either case it incorporates a substantial safety margin. The figure shows an example of a sign used to inform about the compliance distance for RF workers. It is also possible to determine a three-dimensional (3D) compliance boundary around an antenna. The region inside the compliance boundary is often called the exclusion zone. The advantage of defining a compliance boundary is that it specifies the compliance distance in all directions. Usually, base station antennas are highly directional and therefore the RF level behind the antenna is much smaller than in front of it [9].

In principle, RF levels decrease rapidly when a person moves further away from the transmitting antenna. For each antenna, the RF level can be measured based on its electrical characteristics. The distance at which the RF level is always below the RF limit is known as compliance distance. The compliance distance may be based on the reference levels or an SAR evaluation; in either case it incorporates a substantial safety margin [12]. The occupational exposure limits for RF fields: Action values - external electric and magnetic field strength, induced body current and exposure limit values - Peak SAR (10g), whole body average SAR, induced current density (<10MHz).

It is also possible to determine a 3Dcompliance boundary around an antenna. The region inside the compliance boundary is often known as exclusion zone. The advantage of compliance boundary is that it specifies the compliance distance in all directions. Usually, BS antennas are highly directional and therefore the RF level behind the antenna is much smaller than in front of it.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [13] specify an averaging time of 6 min. for determining the exposure level. Therefore, an RF level exceeding the reference level for a short period does not necessarily mean that the RF limit has been exceeded. In practice, this means that even if people walk through a compliance boundary zone, they are unlikely to be subject to overexposure. However, the averaging time should only use with expert advice. In Fig. 2, the first boundary shows the danger zone, where the distance very near to the BS and distance from first boundary to second boundary is the occupational distance limit and distance beyond this is the safe zone for general people

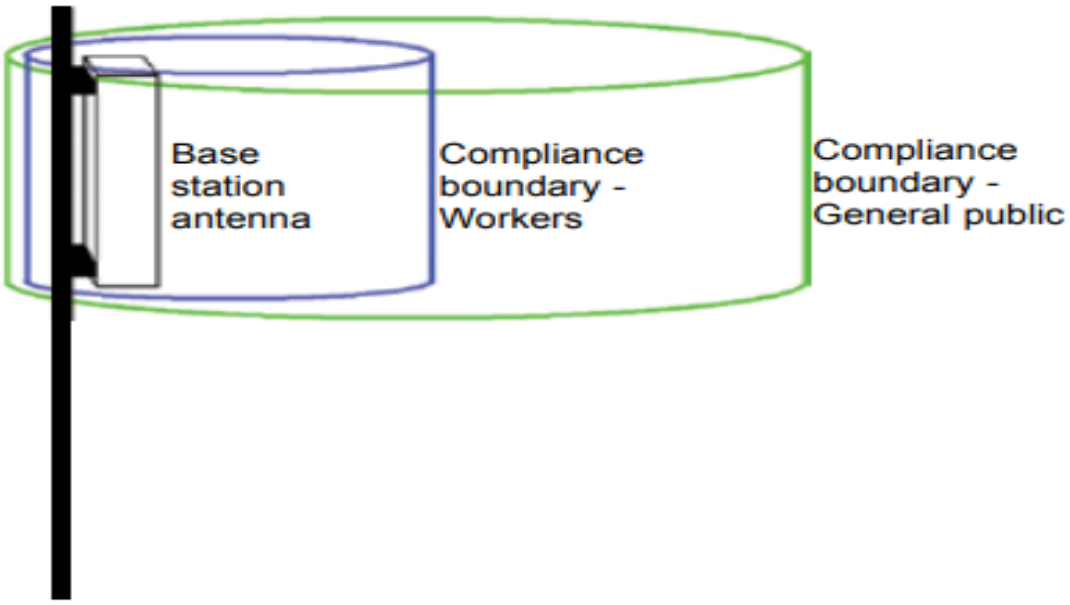


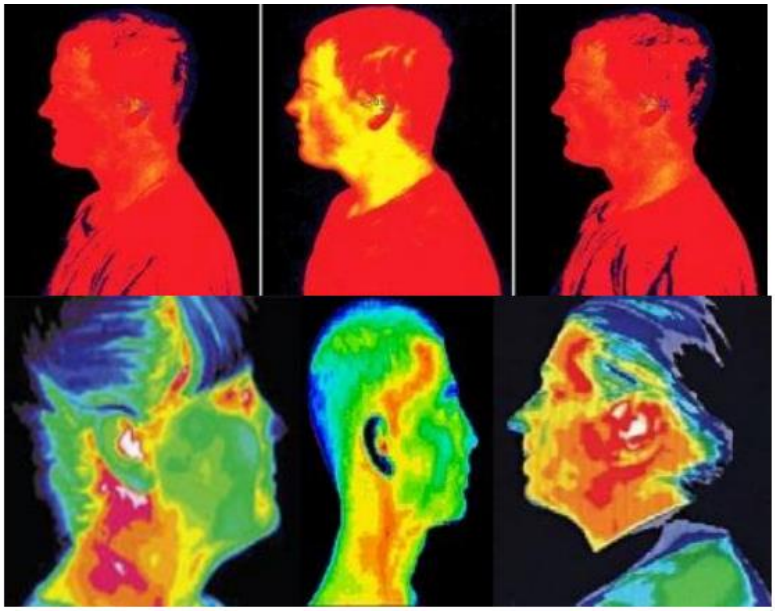
Figure 2 [9]

Thermal Effect:

This effect of cellular phone radiation comes from two aspects:

- First one when the user is using the cellular phone, the phone is transmitting and receiving by its antenna and the microwave exposure is partially absorbed by the user's head and other body tissues.
- Second, ions in the cells in human body which can be turned into electric current by giving required amount of frequency, this electric energy also gets into heat energy as the dielectric loss exists in human body.

The World health organization (WHO)/International Agency for Research on Cancer (IARC) has classified RF-EMFs as possibly carcinogenic to humans, based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use [10]. A group of German doctors found an increased incidence of cancer in patients living near mobile phone towers. The study found that after five years of exposure, people had three times the risk of developing cancer of those living further from the transmitter [11]. However, most of the people don't know that they are having the sleep disorder and concentration problems due to EMF radiation or the people are less aware of it. And being a heavily populated country, this study looked at the effects of phone tower radiation among people living near ten GSM-BS antennas.



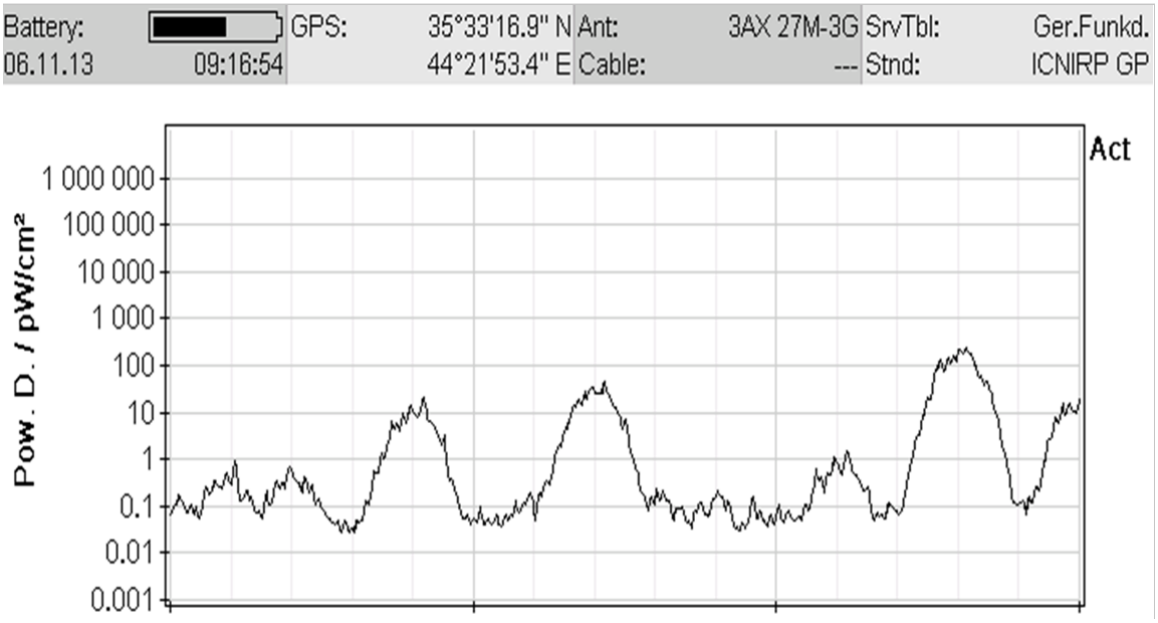
Results and Analysis:

Practically, SAR was measured by using a power density device named by Narda Tool and this device measures the amount of power divided by the unit area (watts / square meters) or (milliwatts / square centimeters). We calibrated the device to take measurement samples within the frequency spectrum used by starts from 948.4 MHz to 959.8 MHz. These readings were taken from one of the site towers in Sulaymaniyah, and it is clear that the values of the emission power density do not exceed the limit allowed by the Iraqi Ministry of Environment (0.4 mW/cm2). On the other hand, we do not forget the effect of the mobile phone itself on the human being, as it is closer and may affect the person clearly if it is not used correctly as the mobile phone emits radiation in all directions, and part of this radiation is distributed over the human head.

Distance	**Power density**
0 m	80 nW/cm^2
122 m	60 nW/cm^2
140 m	50 nW/cm^2
190 m	40 $nWcm^2$
290 m	20 nW/cm^2
400 m	550 pW/cm^2
650 m	90 pW/cm^2
1.3 Km	60 pW/cm^2
1.75 Km	30 pW/cm^2

The readings were taken at different dimensions and in different shapes. The readings were taken straight and circularly and the readings were processed to be displayed on a Google Map based on the coordinates provided by the (GPS) attached to the measuring device.

And



Below are some recommendations to decrease the influences of SAR and reduce exposure to RF energy by the following steps:

1. Use the headphones or built-in speakerphone.
2. Do not place your hand in front of the broadcast antenna on the mobile phone.
3. Reduce the use of the phone in a place with poor coverage.
4. It is necessary to inform the telecommunications companies about coverage problems, in the public interest.
5. The mobile phone uses Power Control technology, where the phone reduces the ability to broadcast if the phone is under good coverage, meaning that the better the coverage, the less the impact of the phone.
6. Do not use the phone in places where electronic devices are available, such as hospitals and planes.
7. Do not leave the phone within the reach of children.
8. A final point is the shape that the towers give places, as their shape may be inconsistent with the place. There are many solutions for this, including the Pico Site and the Camouflage.
9. The Pico Site is a solution for buildings where a link is provided between the building to be covered and the mobile phone network. Inside the building, small antennas of different types are installed to cover the building completely and with as little capacity as possible.

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