

# MEASUREMENT THE ELECTROMAGNETIC RADIATIONS EMITTED FROM CELLULAR BASE STATIONS AND STUDY THEIR EFFECTS ON HUMAN HEALTH

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**ABSTRACT:** Electromagnetic fields represent a form of emitted energy that is absorbed by charged particles, it can cause harm to human body depending on the density of radiated power and the range from the source. The aim of this research is to investigate the implications of EM radiations from the mobile cellular Base Station to the body. A cellular mobile network power density tester model (EMF Strength Meter 480846) has been used to measure the received power near the three Asia cell base station in Kirkuk city. In the first measurement conducted at a constant height (1meter) above ground level for different distances ( 0-200 meters) while the second measurement was conducted at a constant distance (200 meters) for different elevations above the ground surface for different human body areas. Resulted indicates that the maximum measured power density is about  $(1.7 \text{ nW/m}^2)$  and  $(0.002 \text{ nW/cm}^2)$  at (200 m) distance from the antenna and be lower as moved away from the antenna. Comparison these results with the limited values indicate that the levels of power density are below the limitations of exposure set by the World Health Organization.

**Keywords:** EMR, BS Transmitter, Distance, Frequency, Power Density, ill-Health, Radiation

## 1. INTRODUCTION

Electromagnetic radiation or ( EMR ), as well as other waves, consider as an important media to carry signals from a source to the desired destination which can be either data, voice or image. The EMF propagates at the light speed of in free space, so it can be modulated, transmitted and received while conveying the necessary information). EMR is a form of energy which can be absorbed by the charged particles as it travels through space. The effects of EMR on biological systems depends on both radiation's power and its frequency. In case of lower frequencies ( up to those of visible light such as radio or microwave. Heating effects are damage that may happen to human cells or other beings due to exposure to such radiations while damage to living cells by may be larger than that happen by the simple heating [1].

The technology of cell phone has revolutionized the communications field around the world and especially in the developing states due to its advantages, especially in the increasing number of benefits of the application. At every home has been recorded that at least one device per person; kids in schools are allowed to have their cell phones in most Countries which result in increasing the number of cell towers in order to provide service to all the cell phone users[2]. Cell towers are usually randomly situated in some places in countries such as Iraq; some towers had been located close to peoples' homes, schools or market areas. In some countries, some researchers have been concerning about the associated health risk due to radiation from cell phone and cell tower. While some are saying that there is no health effect from the phone's technology due to either lack of proper knowledge or other reasons[3]. Usually, every cell phone device has a Specific 'Absorption Rate' (SAR) with the limit  $1.6\text{W/Kg}$ , which is calculated to be 6 minutes or (360 seconds) per day usage by any person. According to the SAR limits, a person should not be allowed to use his cell phone for more than 24 minutes or (1440 seconds) per day to abide by the safety standards[4]. Unfortunately, the majority of the cell phone users do not have the proper knowledge of its hazards of prolonged exposure, as a result, most of the them use cell phones for more than 2 hours in a day without knowing the health damage it could cause if exceed the limits. For good

planning, cell phone base station must be designed in such a way that mobile phone able to transmit or receive enough signal for proper communication up to some kilometers. Some of such towers are often mounted closer to the residential buildings in order to provide good mobile phone coverage for all users. These towers must work non-stop, so millions of people reside close to these high radiation towers without knowing the possible risks of such radiations that can cause damage to their health [5].

## 2 Biological effects :

Due to the widespread of cell towers, the mobile phone effect radiation on the health of human being is being the main subject of some researchers. Mobile phones operate electromagnetic radiation in the microwave range. So, as a result of installations of the mobile base station, there is additional electromagnetic radiation occurs in the living areas. Consequently, when the level of this radiation keeps growing, it threatens public health problems looming from the same threat due to the part of the radio waves emitted by a mobile telephone handset are absorbed by the body: Radiations from cell phones, both the radiation from phone devices and from antennas carrying the microwave signals, which some studies have linked to the development of some illness such as brain tumors or genetic damage [6].

## 3 Literature Review

There are some previous studies on electromagnetic radiation measurement such as :

FU *et al* measured the level of indoor electromagnetic radiation, on which further epidemiological investigation of the relation between the level of this radiations and some health effects may be based[7].

Halim *et al* was conduct another radiation measurements with a detector type Geiger-Mueller, Monitor 4, calibrated by Cesium 137 every month during 12 months to detect the actual background radiation rate around base station[8].

In Iraq, Sabah in his study, he was conducted at various areas near the Asia cell towers inside some residential areas in Kirkuk city which found that the radiation levels were within the recommended levels[9].

In Spain, Oberfeld found in his study significant health effects among people living in the vicinity of mobile phone base stations could suffer from fatigue, sleeping disorder, concentration loss [11].

In Germany, Eger et al (2004), who examined the health of the people living close to cellular antennas and observed that there is no risk from exposure to such radiations [10].

**Radiation acceptable limits :**

The radiation acceptable limits adopted in some countries is given by ICNIRP guidelines for the safe power density of  $f/200$ , where frequency (f) is in MHz. So, for GSM900 transmitting band (935-960 MHz), power density is  $(4.7W/m^2)$  while for GSM1800 transmitting band (1810-1880 MHz), it is  $(9.2W/m^2)$  as shown in the table (1)[12].

**Table (1): Radiation acceptable limits set by (ICNIRP)[12]**

Frequency	ICNIRP Radiation
900MHz	4.5 Watt / m <sup>2</sup>
1800MHz	9.0 Watt / m <sup>2</sup>
2100MHz	10.5 Watt / m <sup>2</sup>

According to the ICNIRP guidelines, for simultaneous exposure to multiple frequency fields, the sum of all the radiations in a particular area must be taken into consideration. there, the sum of the all the radiation from a base station mast serving two or more service providers' Bio-Initiative report in 2007 was suggested some of the proposed maximum exposure levels as illustrated in table (2).

**Table (2): Maximum exposure levels set by ( BioInitiative report).**

No.	Maximum exposure levels.	Health effect
1.	Less than 0.1 $\mu W/m^2$ (0.00001 $\mu W/cm^2$ )	No effect
2.	0.1 - 10 $\mu W/m^2$ (0.00001 to 0.001 $\mu W/cm^2$ )	Little effect
3.	10-1000 $\mu W/m^2$ (0.001 to 0.1 $\mu W/cm^2$ )	More effect
4.	Greater than 1000 $\mu W/m^2$	High effect

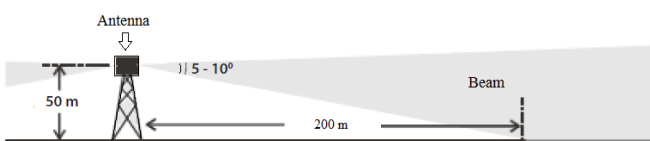
**METHODOLOGY**

Power density can be defined as the power per area normal to the direction of wave propagation and often expressed in Watts per meter square (W/m<sup>2</sup>), milliwatts per meter square (mW/m<sup>2</sup>), or in microwatts per centimeter square ( $\mu W/cm^2$ ).

The received power along the high way road and the commercial zone has been measured in two steps :

- In the first measurement conducted at a constant height ( 1 m) above ground level for different distances ( 0-200 meters).
- The second measurement was conducted at a constant distance ( 200 m) for different elevations above the ground surface.

Coverage of a base station antenna is illustrated in figure (1).



**Fig. (1): Coverage of a base station antenna.**

**First step:**

{Asia cell-A}, {Asia cell-B} and {Asia cell-C} are vertical dipoles of transmitter antennas that are fixed at different heights on a metal tower with a structure that depending upon the nature of the buildings type in Kirkuk city. Specifications of the three base stations are indicated in table (3).

**Table ( 3 ): Specifications of the three {Asia cell} base station.**

No.	Specifications	Asia cell - A	Asia cell - B	Asia cell - C
1.	Height of antenna	35 m	37 m	29 m
2.	Transmitting frequency (fc)	900/1800 Mz	900/1800 Mz	900/1800 Mz
3.	Radiated power (Pr)	44 dBm	42 dBm	19 dBm
4.	Antenna gain (Gr)	15 dBi	16 dBi	49 dBm
5.	Effective Isotropic Radiated Powers (EIRP)	64 dBm	61 dBm	66 dBm
6.	Minimum received power (P <sub>min</sub> )	104 dBm	100 dBm	98 dBm

**Second step:**

In this method, measurement of receiver power and the distances from the antenna has been taken at different points on the resident or commercial buildings by moving from the base station in some directions of Kirkuk city the city. This area was chosen because of the closeness of the buildings to the transmitting base stations. The readings had been taken over a time of two hours at one-hour intervals and this repeated for two days. The position of the three Asia cell base stations in Kirkuk governorate is shown in figure (3).



**Fig. (2): Position of the three Asia cell base stations in Kirkuk governorate.**

If we consider the transmitted signal from cell towers, Power density  $P_d$  at a range  $R$  is:

$$P_d = \frac{P_t \cdot G_t}{4\pi r^2} \dots \dots (1)$$

Where :

$P_t$  = Transmitted power in (Watts).

$G_t$  = Gain of the antenna.

$r$  = Range from the antenna in (m)

The power that can be received  $P_r$  by an antenna at a range  $r$  is :

$$P_r = \frac{P_t \cdot G_t \cdot area}{4\pi r^2} \dots \dots (2)$$

The power that can be received  $P_{rad}$  by absorbed by the human body is :

$$P_{rad} = P_t \cdot area \dots \dots (3)$$

The human body area can be measured as illustrated in figure (3).

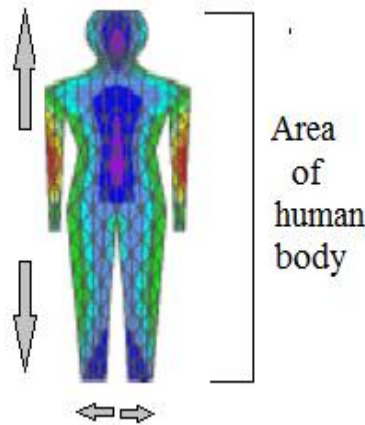


Fig. (3) : Measurement of the human body.

**Practical measurement**

Experimental measurements were collected in the first and second steps using the cellular mobile network analyzer (Model Sagem OT160) which has the capability to measure the signal power in (dBm) as shown in figure (4).



Fig.(4): EMF (480846) strength meter.

**Table (4): Absorbed power in human body from {Asia cell-A}base station.**

Area (cm <sup>2</sup> )	$P_d$ (nWcm <sup>2</sup> )					
	54.74	14.00	1.46	0.72	0.30	0.06
320.12	54.74	14.00	1.46	0.72	0.30	0.06
842.80	144.12	34.12	3.62	1.65	0.61	0.09
1094.34	187.13	45.43	4.71	2.34	0.89	0.12
1276.70	218.32	52.83	5.49	2.70	1.03	0.15
1518.92	259.74	63.67	6.53	3.08	1.23	0.17
1734.00	296.51	73.40	7.46	3.60	1.40	0.19
$P_{rad} = P_t \cdot area$	0.171nW	0.0406nW	0.0043nW	0.002nW	0.0008nW	0.0001nW

Table (5): Absorbed power in human body from {Asia cell-B}base station.

Area (cm <sup>2</sup> )	$P_d$ (nWcm <sup>2</sup> )					
	65.36	13.77	7.30	3.68	1.25	0.06
325.02	65.36	13.77	7.30	3.68	1.25	0.06
840.80	174.46	36.24	19.22	9.69	3.29	0.17
1024.34	226.53	47.07	24.95	12.58	4.27	0.22
1272.70	264.28	54.90	29.11	14.68	4.98	0.26
1509.92	314.42	65.31	34.63	17.47	5.92	0.30
1722.00	358.94	74.56	39.54	19.94	6.76	0.35
$P_{rad} = P_t \cdot area$	0.043nW	0.0289nW	0.0248nW	0.0145nW	0.0039nW	0.0003nW

Table (6): Absorbed power in human body from {Asia cell-C}base station.

Area (cm <sup>2</sup> )	$P_d$ (nWcm <sup>2</sup> )					
	67.36	12.76	7.40	3.78	1.45	0.08
337.02	67.36	12.76	7.40	3.78	1.45	0.08
840.80	173.46	36.24	19.02	9.69	3.18	0.27
1024.34	228.53	48.08	25.96	12.58	4.27	0.22
1362.70	264.28	57.90	29.01	14.68	4.98	0.26
1500.92	314.42	67.31	34.63	17.47	5.92	0.30
1712.00	358.94	71.56	35.51	19.94	5.73	0.45
$P_{rad} = P_t \cdot area$	0.0391nW	0.0229nW	0.0228nW	0.0115nW	0.0039nW	0.0002nW

**RESULTS:**

Electromagnetic radiation levels has been measured as power density in (mW/cm<sup>2</sup>) which is, in fact, represent the energy flow rate per area. The received signal powers were recorded in (dBm), according to ranges in (m) from the antenna. To determine the received power or radiation by the human body who lives or passing through the mobile cellular signal network of a transmitting tower, his area as an object measured in (cm<sup>2</sup>) has been considered.

The absolute power of a signal often is measured in wattage while the decibel system can only describe the relative power. The standard for transmitted power measurement is in mWcm<sup>2</sup> and (1dBm = 0.001258925W )

Tables (5) and (6) shows the absorbed power calculated by multiplying the received signal power at a particular distance by the possible human area at that point while figure (5) illustrates the graph of absorbed power in human body from {Asia cell-A}and{Asia cell-C}base station against distance.

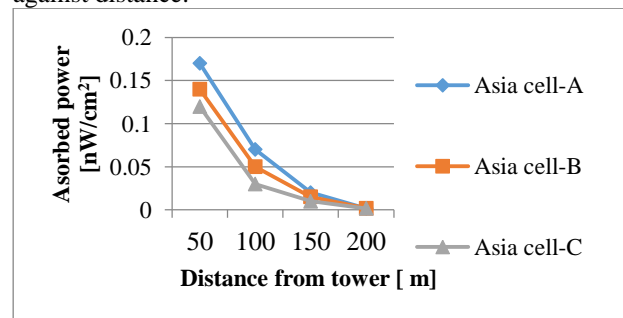
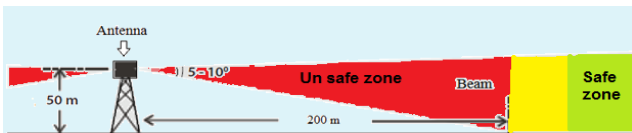


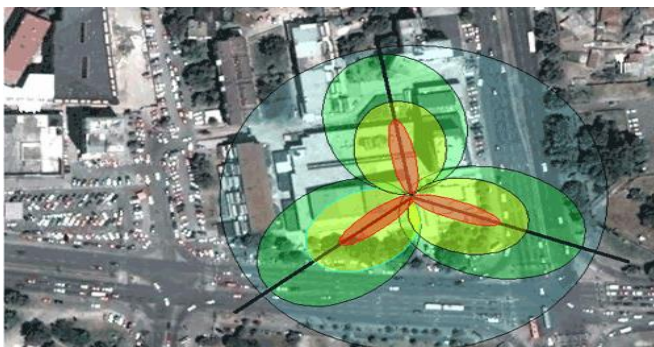
Fig.(5) : Graph of absorbed power for{Asia cell-A}and{Asia cell-A}base station against distance.

**DISCUSSION:**

The graph of the absorbed power against distance from the BS is close to linear from 0m to about 200m with high values. From 200m and more from the base station, the power density is maintained within a lower value as it gradually reduces to zero as the distance increases. Figures 3 to 6 show that from 0m to 200m, the power density it is not enough to cause some degrees of health problems to people who live within such areas as indicated in the Bio-initiative report. Power densities emitted from the three Asia cell base stations from (0 to 50 m) generates the highest level on the human body which increases with increasing the area of the human body while this level decreases with increasing the distance from the antenna. So, in addition to the area of the human body, the distance from the antenna is considered as the main factor that determines the level of power absorbed by the human body. The shorter the distance of the human body from the antenna, the higher the rate of power absorbed by the body which results in a higher possibility of health problems. According to the result obtained it is recommended that people do not live close to or build new houses within 200 m from the base stations. Save and unsafe zone is illustrated in figures (6) and (7).



**Fig. (6): Save and unsafe zones.**



**Fig. (7): Top view of the antenna with tree radiation sectors.**

**CONCLUSION**

At some areas in Iraq after 2003, a huge number of cellular phone towers are being mounted on the roof of some residential or commercial buildings such as homes, banks or hotels. So, the radiated power that can be absorbed by multiple phone base stations should be considered as well since every Iraqi person now have one or more phone device. The investigation and measurement of electromagnetic radiations from the Asia cell base stations to human body was successfully had been conducted and based on the results analysis, it was proved that the radiated power density measured was high from (0 to 50m) from the antenna while the measurement at ranges > 50 m of absorbed power was very low ( 0.17nW). Therefore, it will not be safe to live within (50 m) radius from the antenna position in which the level of power absorbed may lead to a negative effect on the human health problems such as loss of concentration, headache. From results obtained, It is recommended that there should be some public awareness

regarding the possible negative effects of electromagnetic radiation emitted from the cellular mobile transmitters which can be absorbed by the human body and study suggests the possible ways to avoid its resulting harness. The Iraqi communication agency should make and implement a rule to ensure that the erection of such transmitters must be established for >200m away from the human residential areas and the erected antennas that fall within 200m from residential areas can reduce the radiated power density to a reasonable level. The agencies should also ensure that people do not live close to or build new houses within 200 m from the base stations. It is, therefore, recommended that (50µW/m<sup>2</sup> - 100µW/m<sup>2</sup>) can be considered as a safe power limit.

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