Radio Frequency Radiation Power Density measurements at Mobile Base Stations in Alam City

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ABSTRACT

In Iraq, the number of mobile phone users has increased dramatically During the past 15 years. Mobile network technologies are rapidly expanding worldwide, increasing the number of smart devices and mobile base stations. Placing mobile base stations in heavily populated areas, such as close hospitals and government departments, has triggered severe fear about potential health risks. The Iraqi Ministry of Environment released guidance for measuring magnetic waves emission by base stations used in mobile networks.

TEMS technology and OpenSignal software version 7.19.2 was used to calculate the electromagnetic power density emitted from mobile base stations (downlink) and cell phones to base stations (uplink) in this research paper. TEMS technology evaluates and measures the electromagnetic power density. OpenSignal software used to know the location and cell ID of the cellular tower, The studies were conducted in 200 meters of an AsiaCell Mobile telecommunications provider's tower in Al-Alam city in Saladin governorate. The data was collected for both uplink and downlink. The quantified values were compared to the antenna prediction sequence and the used safety guidelines to enforce compliance with all these restrictions. All of the measurements value were within the limits.

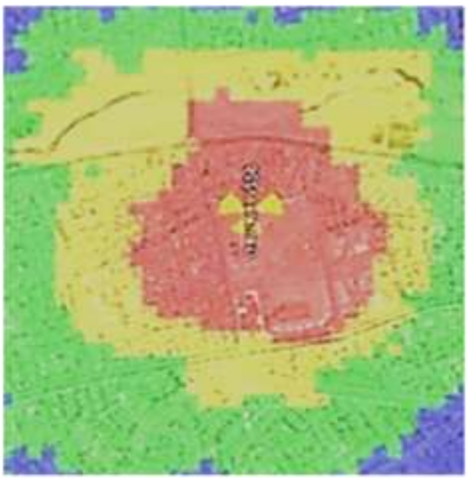

Fig (1) prediction of coverage in Google map.

Keywords: EMR, GSM, BS, non-ionizing radiation

I. Introduction

Electromagnetic radiation (EMR) is emitted by a variety of natural and human-made factors. The sun's EMR makes the earth warms. Our eyes sense a part of this EMR spectrum called visible light. Radiofrequency is also one of the forms of EM spectrums. These frequencies started in (3kHz) and end in (300 GHz) as [1] . Fig (2) shows EM waves with various frequencies. Each set of this frequency component does have its own identity, property, and characteristic. EMR is categorized into two kinds: ionizing and non-ionizing radiation (IR, NIR). The radiation in the IR class has sufficient power to detach attached electrons with an atom. These ionized atoms could pose a health danger. EMR in the NIR category does not have enough energy for ionizing atoms [2]. Electromagnetic waves are the most popular and essential medium to transporting signals from either a source to the final destination; these signals can be voice, data, or video. These signals travel at the speed of light (3 x10 ^ 5) km/s) in open space [3].

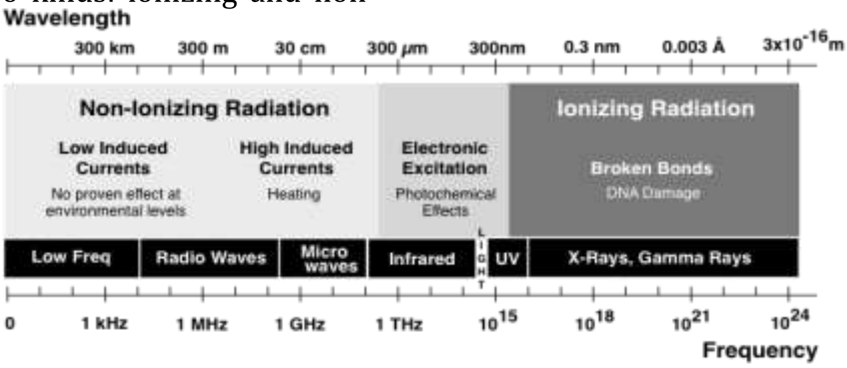

Fig (2) Electromagnetic spectrum.

A human body part is often exposed to electromagnetic radiation. Electronic equipment like fans, dishwashers, microwaves, smartphones, and telephony base stations are always around us [4]. The smartphone, also known as a cellphone, is an essential part of modern culture. Cell devices are being used by more than half the population in several parts of the world, and the cellphone economy is increasingly expanding. In some regions of the world, cell phones are the only or even most trustworthy phones [5].

Because the use of electromagnetic appliances in the work environment increased in the 1970s, the effect of these device's emissions on public health to the human a animals became more popular. Public debates, concerns, and issues about the possibility of harmful effects of exposure to Radiofrequency radiation emitted by cellular mobile elements have also grown [6]. Several more guidance and restrictions were approved by many international organizations to avoid possible health risks from long term and short term exposure to electromagnetic radiation. These organizations like the Federal Communications Commission (FCC) [8], Institute of Electrical and Electronics Engineers [7], IEEE, and the Australian Radian Protection and Nuclear Safety Agency (ARPNSA) [11], the International Committee on Non-Ionizing Radiation Protection (ICNIRP) [10].

The positioning of transmitters and telecommunication antennas surrounding residential and employee sections at irregular arrangement raises serious fear, as does daily exposure to an electromagnetic environment's radiation. Particularly potential for health risks from exposure to EMR energy emitted by cellular networks transmitters. Even though phone telecommunications are using the microwave scope of the electromagnetic spectrum, that's the case. The body of a human is penetrated by electromagnetic waves of various frequencies and levels of power. Absence of public knowledge, a lack of directives with the appropriate strategy for cell phone tower setup, controlling, successful implementation, as well as control at any and all levels by government bodies, and an absence of clarity locally and nationally accredited protocols for giving approvals for the setup of Radio Frequency antennas have all made a significant contribution to the citizenry's fear of being exposed to RF EM field emissions, In Iraq, there are three major mobile wireless telecommunications suppliers: Korek, Zain, and Asiacell Company. Because the testing was completed for Asiacell company BS's, in Al-Alam town (a town in northern Iraq), we are only focused on (GSM) technology used by this telecom operator. BS signals must spread out more to support mobile phones; these towers are considered as part of a wireless mobile network in order to establish a connection between the mobile device and the network. As a result, Asiacell Company's communication BS are allocated all across Al-Alam City to ensure that the users have access to services, When the number of towers (BS) increases, so will the number of people who are exposed to the electromagnetic waves emitted by these towers in Alam city. as seen in Fig3.

Fig (3). Disruption of AsiaCell BS towers in alam city.

II. The Cellular System:

A Continuous growth in demand for cellular communication services necessitates the installation of a massive number of base stations. Wireless communication technologies account for more than 65 percent of RF radiation exposure, with mobile phones being the most significant contributor [14].

Because of the limited number of frequency bands, the mobile radio network only has a small number of channels available for speech. The 900 GSM system, for example, has a bandwidth allocation of 25 MHz (890-915) for uplink and 935-960 MHz for downlink. This equates to a maximum of 125 channels, each with a 200 kHz bandwidth. A maximum of eightfold for each carrier in the Time Division Multiple Access (TDM) technique, It's also possible to achieve a maximum of 1000 channels. Barricade bands, on the other side, decrease this percentage. A channel must also be spatially recovered in a geographical region to start serving millions of users. The principle of spatial frequency reusability led to advances in communication technologies. The frequency spectrum of Global System Mobile (GSM) can be seen in Table I.

Table (1). GSM frequency spectrum of company in iraq.

System	Frequency		Bandwidth	Channel Number
	Uplink	Downlink		
EGSM	880-890	925-935	10 MHz	50
GSM	890-915	935-960	25 MHz	125
GSM	1710-	1805-	75	375

1800	1785	1880	MHz	
GSM 1900	1850-1910	1930-1990	60 MHz	300
UMTS	1920-1980	2110-2170	60 MHz	300
Korek	880.2-891.8	925.2-936.8	11.6 MHz	58
Zain	891.8-903.4	936.8-948.4	11.6 MHz	58
Asiacell	903.4 - 915	948.4-960	11.6 MHz	58

This channel spacing produces a different number of frequency bands for each of the more commonly used frequencies for GSM system operation. There are 124 carrier frequencies in the GSM 900 band, while there are 374 carrier frequencies in the GSM 1800 band. The absolute radio frequency channel numbers (ARFCNs) for each band are (1-124) for GSM 900 and (1710-1785) for GSM 1800 [15]. By using (TEMS) technology in alam city we found the the result in Tabel 2.

Table (2). Data read by TEMS technology for Asiacell towers in alam city.

Cell ID	Type of Technique	Frequency (MHz)	Distance	Measured Power
18294	UMTS	2137.4	100	-53
19824	UMTS	2132.6	50	-55
21823	UMTS	2134.4	200	-57
18825	DCS 1800	1853.8	100	-51
15296	DCS 1800	1853.4	50	-53
22512	DCS 1800	1854.6	800	-79

III. Mathematical calculations

In our research We will use tow formulas as below to measure the received signal (Pr) that's been sent from a specific antenna (BS).

formula: $$Pr = Pt * Gt * Gr * \{\frac{\lambda}{4\pi D}\}^2$$ first

Where:

Pr: power received.

D: is the distance between the transmit power transmitter and the destination.

Gt: Gain of the transmit antenna

Gr: Received Antenna Gain.

Formula (1) is normally written in dBm rather than watts to make it easier to understand.

The transmitted power is proportional to the received power, antenna gain, and also the square of a signal wavelength, and it is inversely proportional to square of a distance (D). therefore;

$$P_r = P_t + G_t + G_r + 20log_{10}(\frac{\lambda}{4\pi D})$$

As we say that the theoretical calculation was done using equations (1) and (2), and the results are compared to the practical power values (power density that measure).

$$Power\ Density = \frac{P_r * 4\pi * f^2}{Gm * c^2}$$

Where Pd denotes power density, Gm denotes mobile gain, and c/f denotes the wavelength. C stands for the speed of light, which is $3 * 10^8$, and F stands for frequency. As a result, the formula will be as follows:

$$Power\ Density = \frac{P_r * 4\pi * f^2}{Gm * c^2}$$

The following equation are used to calculate the power for all cells:

For UMTS, G t=0, G r=0, P t=30 dBm, and P t=33 dBm .

After the applied the result that founded by (Tems) technology in mathematical equations , the result can noted in next Table III.

Cell ID	Type of Technique	Frequency (MHz)	Distance	Measured Power (dBm)	Theoretical Power	Power Density
18294	**UMTS**	**2137.4**	**100**	**-53**	**-48.95**	**0.00083 μw/m2**
19824	**UMTS**	**2132.6**	**50**	**-55**	**-42.80**	**30.9 μw/m2**
21823	**UMTS**	**2134.4**	**200**	**-57**	**-44.81**	**4.003 μw/m2**
18825	**DCS 1800**	**1853.8**	**100**	**-51**	**-45.01**	**15.743 μw/m2**
15296	**DCS 1800**	**1853.4**	**50**	**-53**	**-39.09**	**62.968 μw/m2**
22512	**DCS 1800**	**1854.6**	**800**	**-79**	**-58.01**	**0.2297 μw/m2**

Table 3. Math calculation results.

IV. An International Criteria For Emr.

The risks of EMR exposure to human health are really a serious problem in nearby areas of TV and radio transceivers, wireless network adapters, cellular BS, and other causes of EMRs. NIR levels generated by these sources, as well as their potential effects on humans, have been the focus of investigation [18]. A biological system is said to be biological when a change in it can be assessed after certain stimuli are introduced.

It has an impact. However, the presence of a biological hazard does not always imply the presence of a biological effect. When a biological effect causes detectable deterioration in an individual's health or the health of his or her children, it is called a safety threat. The biological effects of heating tissue with RF energy are known as thermal effects [18].

The key concern about RF energy exposure began sixty years ago. For those employed in the EM sector (occupational or conditional exposure) and the general public, many international and national standards, recommendations, and regulations for RF energy exposure have been established (public or unconditional exposure). Typically, these exposure recommendations are identical and are focused on established adverse effect levels. These recommendations have a safety margin to protect people from potential health effects from short and long-term exposure to RF radiations. When exposed to an EM source from a distance of 20 cm or less, the power absorbed in the partial or whole body must be compared to the limits and recommendations. The specific absorption rate (SAR) is a metric for determining how quickly the body absorbs electromagnetic energy. The watts-per-kilogram (W/kg) measure of SAR. The value of the threshold SAR determines the recommended maximum permissible exposure (MPE) for power density [2].

Table 4. The MPE reference levels defined by ICNIRP.

Exposure charact-eristics	Range of Frequency	Current density for head and trunk (mA/m2) (rms)	SAR (W/ kg)	Localized SAR (head and trunk) (W/kg)	Localize d SAR (limbs) (W/kg)
Occupat-ional exposure	Up to 1 Hz	40	-	-	-
	(1-4) Hz	40/f	-	-	-
	(4Hz-1kHz)	10	-	-	-
	(1-100) kHz	f/100	-	-	-
	(0.1-10)MHz	f/100	0.4	10	20
	10MHz-10GHz	-	0.4	10	20
General public exposure	Up to 1 Hz	8	-	-	-
	(1-4) Hz	8/f	-	-	-
	(4Hz-1kHz)	2	-	-	-
	(1-100) kHz	f/500	-	-	-
	(0.1-10)MHz	f/500	0.08	2	4
	10MHz-10GHz	-	0.08	2	4

A) **Managed exposure limits**

Frequency range	E-field strengt h(V/m)	H-field strength (A/m)	Equivalent plane wave power density S (W/m2)
Up to 1 Hz	-	1.63 x105	-

(1-8) Hz	20000	1.63 x105/f2	-
(8-25) Hz	20000	2 x 104/ f	-
(0.025-0.82) kHz	500/f	20/f	-
(0.82-65) kHz	610	24.4	-
(0.065-1) MHz	610	1.6/f	-
(1-10) MHz	610/f	1.6/f	-
(10-400) MHz	61	0.16	10
(400-2000) MHz	3f1/2	0.008f1/2	f/40
(2-300) GHz	137	0.36	50

B) **general exposure Limits**

Frequency range	E-field strength (V/m)	H-field strength (A/m)	Equivalent plane wave power density S (W/m2)
Up to 1 Hz	-	3.2 x104	-
(1-8) Hz	10000	3.2 x104	-
(8-25) Hz	10000	4000/ f	-
(0.025-0.8) kHz	250/f	4/f	-
(0.8-3) kHz	250/f	5	-
(3-150) kHz	87	5	-
(0.15-1) MHz	87	0.73/f	-
(1-10) MHz	87/f1/2	0.73/f	-
(10-400) MHz	28	0.073	2
(400-2000) GHz	1.375 f1/2	0.0037 f1/2	f/200
(2-300) GHz	61	0.16	10

It's worth noting that f is the frequency, as shown in the frequency range column. The MPE is clearly frequency-dependent based on these constraints. As a result, the MPE for both GSM 900 and 1800 would be (4.6 W/m2) in the general public and (22.6 W/m2) in the workplace.

When it comes to EMF exposure regulations, the majority of countries do the following: 1) Contain the ICNIRP instructions explicitly, implicitly, or with some guidelines. 2) they build their own national standard. 3) Follow international standards, and 4) issue precautionary environmental recommendations. The ICNIRP guidelines were indirectly adopted by most European countries via Council of Europe Councils and Parliamentary reports [20].

V. Procedures And Materials:

TEMS testing software was used to conduct field research on power density measurement.

This software is an air interface for a real-time diagnostic test tool. Advanced testing functions, efficient analysis, and useful post-processing features are all included. Data is displayed in real-time throughout or is stored in log files for post-processing. This program will display details for each individual cell in the dedicated GSM Mobile network. In particular, trying to draw cells on maps and showing them by name in different windows, TEMS mobile station or TEMS scanner (a dedicated frequency scanner mobile) are used to perform the scanning. The TEMS device is related to the computer through a USP port. When scanning, the TEMS mobile cannot be used as a regular GSM phone (cannot be used for data transmission or voice call). This program will pinpoint the position of the BS and the measurement points in terms of coordinates.

The network output was observed and recorded using the TEMS drive testing phone. The site's network content reports were analyzed. Table 4 details the positioning and specification of a site's antenna.

Table 5: The site specifications.

Longitude	**43.689497**
Latitude	**34.707090**
Height	**22.4 m**
UMTS	**3 transmitters**
DCS 1800	**3 transmitters**

VI. Results And Discussion:

A broadband meter or a (spectrum analyzer) is usually used to calculate EMR. The broadband measure is being used to estimate the total contributions of any and all RF sources in a given frequency band, whereas the spectrum analyzer has been used to identify an RF supply.

TEMS program was used in this analysis. The power density released by ASIACELL sites with GSM 900 and GSM 1800 was responsive to this software.

This services provider's antennas are primarily Kathrein versions. Kathrein antenna is a panel-style antenna that split the area surrounding the BS site into three sectors. Fig (2) displays a Google map GSM location, while Fig (1) shows coverage estimation for the site area, with values (x => -51 dBm) in densely populated urban in red color, (-59 = x -55) dBm in urban in orange color , (-73 = x -59) dBm in suburban in yellow color, , and for values (-89 = x -73) dBm in highway (in-vehicle) in green color, as well as for the values (-95 = x -89) dBm in rural/highway in blue color, Fig (3) represent the power density emitted from (2658) mobile device to the BS (uplink), with One TA represents a distance of 500 meters from the BS's foot. Fig (4) displays the receive signal strength of (2658) customers from around BS from neighbor cells evaluated in dBm. According to Table (V), a power density of both 900 MHz and 1800 MHz must be less than (4.5 W/m^2), and all of the calculated values are less than (4.5 W/m^2).

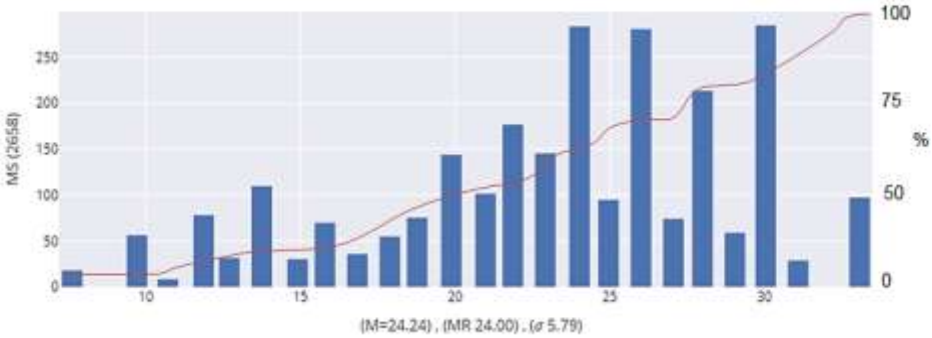

Fig (3) MS TxPower (dBm).

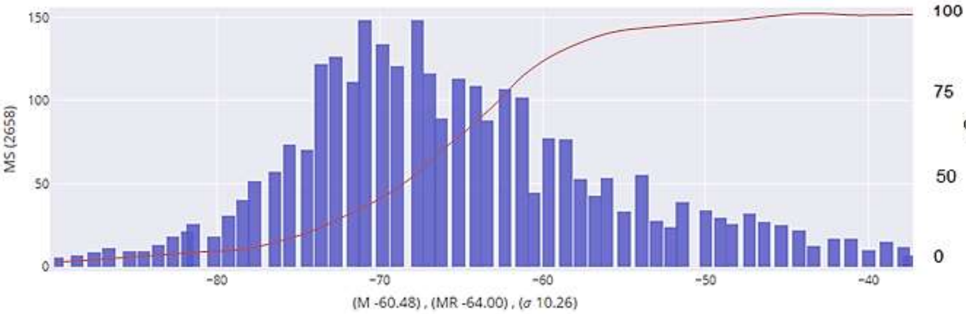

Fig (4) Rx level of neighbor in (dBm).

VII. Conclusions

In this research, The electromagnetic power density was measured in various locations around a BS in a densely populated region in Alalam city, Iraq, The radiated power from mobile BS is affected by the number of users making phone calls at the same moment. As a result, the radiation intensity varies between the sites, with each having its own variations based on the time, distance, landforms and weather.

The electromagnetic waves depend on three basic variables: frequency, wavelength, and energy . there is an inverse relation between frequency and wavelength, the radiation of MS, and BS does not fall under ionizing radiation , but the absorbing time is one of main causes to many effects on human health , we can note the headache ,fatigue and insomnia appear on people who use phones for long time.

In general, the strength of the RF field at any measurement point can change over time. This variance is caused by changes in propagation loss between both the measuring point and the source. and source transmitting power.

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