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Evaluating the Electro Magnetic Fields Radiation of the Cell Sites and their Environmental Effects: A Case Study of Mosul City

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Abstract

Cell phones, also known as mobile or portable phones, have become an essential part of contemporary communication technologies. In some regions of the world, they are even the only available means of communication, as they are so well-liked for allowing people to communicate with one another no matter where they are. Cell phones are becoming increasingly popular, with more than 50% of people in some nations owning one. The industrial community anticipates that by the year 2030, there will be more than 8 billion users worldwide. To accommodate broadcast and reception, more towers are being built. These stations, which are radio antennas, work to protect connections with cellular telephone equipment while using minimum power. The goal of this proposed study is to measure the electromagnetic fields radiated by cell phone towers and their effects on the local environment in a selected area of Mosul, Iraq. The results will then be compared to international standards, and evaluated to help develop methods for protecting people's health, and solutions to the issue will be offered.

***Keywords*:** Electro Magnetic Fields (EMF), Radiation, Cell Sites, Radiofrequency (RF), Power Density (S).

تقييم المجالات الكهرومغناطيسية المنبعثة من مواقع البث الخلوي وتأثيراتها على بيئة مدينة الموصل

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الخلاصة:

أصبحت الهواتف المحمولة، التي تسمى أحيانًا الهواتف الخلوية، جزءًا لا يتجزأ من تقنيات الاتصالات الحديثة، وفي بعض أنحاء العالم تعتبر الأكثر انتشارًا بين وسائل الاتصالات الأخرى، حتى أنها تعتبر الوسيلة الوحيدة المتاحة للتواصل بين البشر، وهي تحظى بشعبية كبيرة لأنها تمكّن الناس من التواصل مع بعضهم البعض دون أي تأثير على تحركاتهم. في بعض البلدان يستخدم أكثر من نصف السكان الهواتف المحمولة، وينمو سوق هذه الأجهزة بسرعة كبيرة حيث يتوقع المجتمع الصناعي أن يصل عدد مستخدمي الهواتف الخلوية إلى أكثر من 8 مليار شخص على مستوى العالم في عام 2030. ولهذا السبب يتزايد عدد محطات الهاتف المحمول (الأبراج) لتغطية البث والاستقبال في المدن. هذه المحطات عبارة عن هوائيات راديو تعمل بطاقة منخفضة وتعمل على تأمين الاتصالات بأجهزة الهاتف الخلوي. يحاول هذا البحث المقترح قياس المجالات الكهرومغناطيسية المنبعثة من أبراج الهواتف المحمولة وتأثيراتها البيئية في منطقة مختارة في مدينة الموصل في العراق، ومقارنة النتائج بالمعايير الدولية وتقييمها لتحسين أساليب حماية الصحة الشخصية للإنسان ومحاولة اقتراح حلول لهذه المشكلة.

الكلمات المفتاحية : المجالات الكهرومغناطيسية، الاشعاع، ابراج البث الخلوي، التردد الراديو، كثافة القدرة.

1. Introduction

The engineering progress in the field of audio/visual communications resulted in the emergence of topics that did not exist previously as mobile devices and their communication towers, and the spread of these towers in many areas, especially within cities. Nowadays, cell phone towers are dispersed across the roofs of city center buildings which, in turn, cause harm to people without any supervision or judicial sanction. To protect the population and the environment from the effects of wireless communications use which might seriously injure the residents, as well as the risk of the collapse of residential buildings carrying those telecommunications towers, it is prohibited to install towers, relay stations, antennas, or any other wireless communication devices in locations designated for residential use. Citizens have become in great fear and confusion about the matter of these towers, and many have become inquiring about whether there are health damages to these towers and the results of these towers erected amid residential neighborhoods and on roofs of houses. To answer these questions and dispel these fears, the authors tried to shed light on the damage caused by mobile phone towers by studying the issue from all its aspects which assists to reduce the harmful of these towers.

2. Literature Review

Studies and efforts to measure EMF pollution are rather scarce. Typically, they were done in a constrained context, such as a research problem. Measurements of radiofrequency (RF) were conducted by Mantiply and others [1]. It was attempted by Paolino and others to depict this issue graphically and a GIS-based method of EMF was documented [2], [3]. They explained the procedure used to connect the EMF mean to the population of different Spanish cities [4]. Also GIS was used to measure how cell towers radiation affected people [10], [13]. In Saudi Arabia, Al-sahly and others assessed the strength of the EMF near base stations [10]. Kumar measured the power density of EMF in different locations in India [7]. Also, the NTA studied the radiated EMF from cell phone base stations in Nepal and established the maximum and the minimum power densities of EMF near hospitals and residential areas [11]. Electromagnetic exposure which broadcast radio and TV for various locations in Sweden was studied by Abdul Ghayur Khan [12].

3. Theory

Electromagnetic radiation has been defined as radiant energy that behaves as waves propagating through space and as photon particles traveling through space in a vacuum, propagating at the speed of light, usually in straight lines [13]. As seen in Figure 1, the electric and magnetic fields, which make up the electromagnetic wave, oscillate perpendicularly to one another and to the direction in which the wave travels.

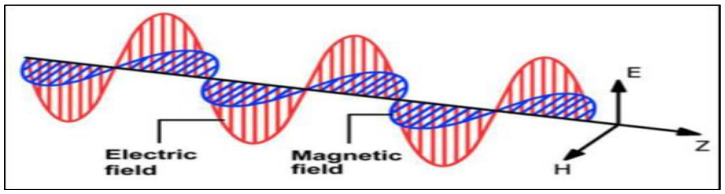

Figure 1. Electromagnetic wave propagation

The symbols E, H, and Z refer to the electrical field strength; its unit is volts per meter (V/m), the magnetic field strength; its unit is ampere per meter (A/m), and the impedance of free space in the direction of the propagation (its value is 377Ω) respectively [18]. The combined effects of these two fields are resulted from the power density (S), which is measured in (W/m^2). These quantities were related by equation (1) [8]:

$S = E^2/3770 = 37.7\ H^2$ ……..... (1)

where:
S = power density (mW/cm^2).
E = electric field strength (V/m).
H = magnetic field strength (A/m).
The impedance of free space=377 ohms, is used in deriving this equation.

Ionizing and non-ionizing radiation are the two main parts of the electromagnetic spectrum. Fortunately, the Non-Ionizing Region (NIR) of the electromagnetic spectrum has minimal energy, where radio waves and microwaves are found which don't cause any danger to human beings if they are not exposed to it permanently [18] as shown in Figure 2.

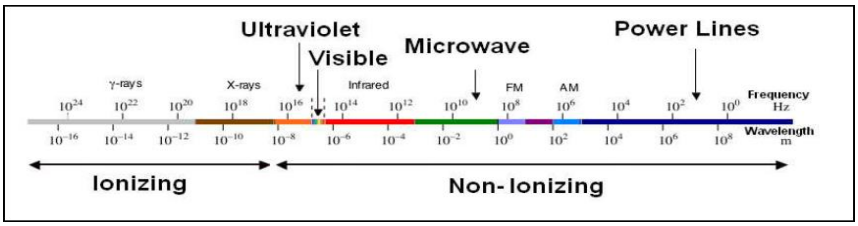

Figure 2. Electromagnetic spectrum

The current work focuses on the microwaves part of the non-ionizing radiation region of EMF emitted from cell phone towers within the city of Mosul. This region includes visible light, microwaves, power lines, low-frequency Ultraviolet (UV), and Infrared Radiation (IR). Many biological effects that are largely frequency dependent are observed for different types of non-ionizing Radiation. Some of these types of radiation can also be harm to living creatures in different ways other than thermally [16], [18]. The International Agency for Research on Cancer (IARC) has stated clearly and in detail that the region of the non-ionizing radiation can cause cancer in humans [12].

4. Research Methodology

The researcher task consists of two parts:

A. Part 1

Measuring the EMF radiated from the cell phone towers in selected areas of Mosul city by using the EMF radiation meter type "TRIFIELD® [16] as shown in Figure 3, and its specifications are described in Table 1 below.

Figure 3. EMF radiation meter type "TRIFIELD®"

Table 1. Specifications of "TRIFIELD®" meter

	AC Magnetic	AC Electric	RF/Microwave
Sensor type	3 axis, true magnitude	1 axis, true magnitude	1 axis
Frequency Range	40 Hz to 100 kHz	40 Hz to 100 KHz	20 MHz to 6 GHz
Accuracy	+/- 4% at 50/60 Hz	+/- 5% at 50/60 H	+/- 20% at 1 GHz
Maximum Range	100.0 milligauss	1000 V/m	19.999 mW/m^2
Sensitivity (Resolution)		1 V/m	0.001 mW/m^2
Sensitivity (Resolution)		0.1 milligauss	

As shown in Figure 4 below, many routes were chosen in Mosul city for measuring the EMF along them. These routes are: [A-B-C-D-E-F-G-H-I].

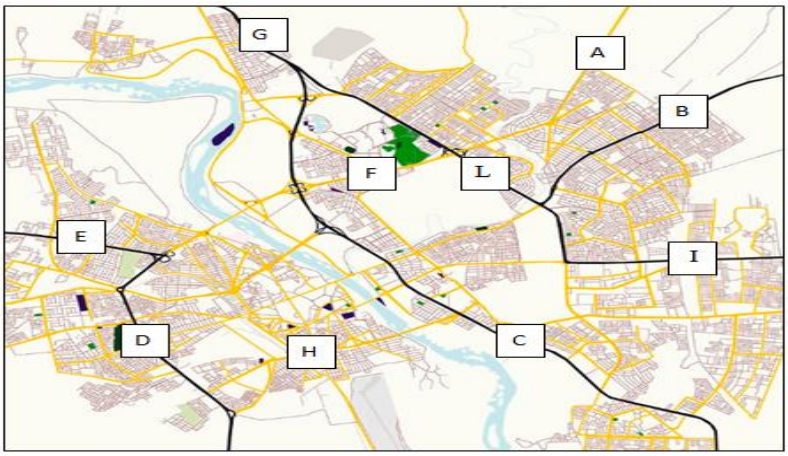

Figure 4. Locations of the routs in Mosul city

Equation (2) is used in calculating the mean values of the power density radiated from the cell phone towers in each section of the routes:

$X_{mean} = \Sigma x / n$ …….....……..……. (2)

whereas

x = the measured value.

n = the number of measured values (in present case n =10).

The researcher measured maximum and minimum values of the radiated power density in (mW/m^2) and calculated the mean values of 10 randomly chosen values of this power in each route; the measurements were scheduled in Table 2 below:

Table 2. Routs [A-B-C-D-E-F-G-H-I]

Route	Max. Power density (mW/m^2)	Min. Power density (mW/m^2)	Mean Value (mW/m^2)
A	2.19	0.052	0.4972
B	3.02	0.77	0.8452
C	1.132	0.068	0.2878
D	3.71	0.044	0.7768
E	3.2	0.2	0.7354
F	2.04	0.007	0,4021
G	1.93	0.12	0.4356
H	3.88	0.912	1.1684
I	2.71	0.415	0.6746

As power density is influenced by measuring conditions such as site variables including geographic nature, nearby population, site specifications, and survey time. The readings vary from one route to another as shown in Table 2. Figure 5 clarifies that the whole city is exposed to an overdose of EMF radiation which means a dangerous situation.

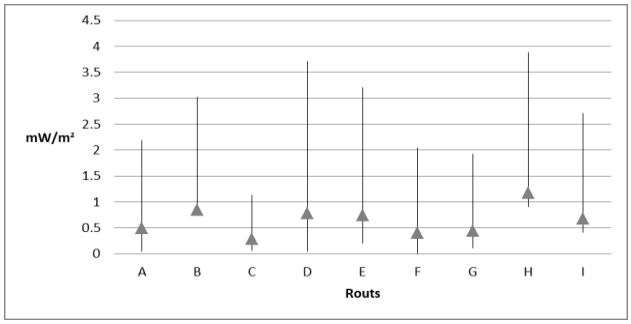

Figure 5. Distribution of EMF radiation in selected routes

According to [16], [18]; for public health protection; it was recommended that humans must not be exposed to a high frequency source whose power density is more than 1mW/m² such as GSM base stations for long periods. Table 3 summarizes this resolution:

Table 3. Guidelines for living areas

Level (1)	Level (2)	Level (3)	Level (4)
No concern at all	Slight concern	Severe concern	Extreme concern
<0.0001 mW/m^2	(0.0001 to 0.01) mW/m^2	(0.01 to 1) mW/m^2	>1 mW/m^2

B. Part2

The sight of mobile phone towers covering the roofs of some buildings has become familiar after the cash money offered by telecom companies tempted the owners of these buildings to allow

these companies to erect their towers. Citizens have become in great fear and confusion about the matter of these towers, and many have become inquiring about whether there are health damages to these towers and the results and consequences of these towers being erected amid residential neighborhoods and on the roofs of houses. To answer these questions, dispel those fears, and clarify the damages, the following case has been studied:

Two houses (A and B) in a specific district of Mosul city. A cell phone tower is erected on the roof of house (A) as shown in Figure 6; the distance between the two houses is about 7 meters. The EMF radiations were measured in house (B) and their values as shown in Table 4.

Figure 6. A cell site

Table 4. Measured EMF radiations in hours B

	Location	Meter's Reading (mW/m^2)
1.	In front of the main entrance door to house "B"	1.349
2.	The roof of house "B"	9.605
3.	Reception room	0.005
4.	Living room "1"	0.024
5.	On the street in front of house "B"	2.100
6.	The kitchen	0,009
7.	Living room "2"	0.017
8.	Front balcony	2.831
9.	The bedroom on the ground floor	0.172
10.	The bedroom on the first floor	1.306

The curve in Figure 7 clarifies the distribution of the radiation in house (B). It shows that the residents of this house are at risk. Only locations 3 and 6 are in the safe zone, level 2 of Table 3, locations 4, 7, and 9 are in level 3 of Table 3, and locations 1, 2, 5, 8, and 10 are in level 4 of Table 3, which means that only 20% of the locations in the house can be considered in the safe zone and other locations are risky.

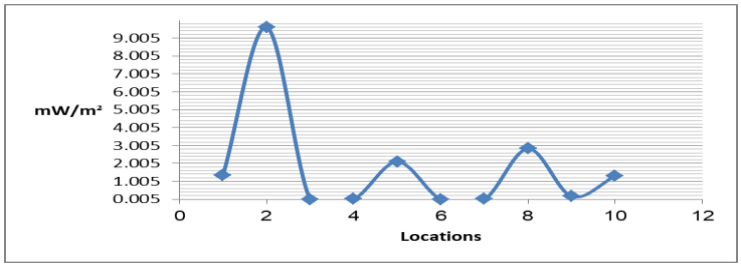

Figure 7. Levels of exposure

Figure 8 shows the area within a circle with a radius is 300 meters and its center is the cell site mentioned above. This circle indicates the approximate limits of the high radiation exposure area from the tower.

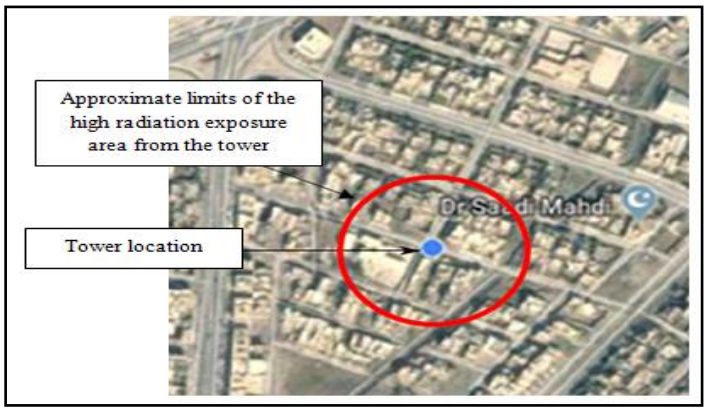

Figure 8. Aerial photo of the chosen district

The curve in Figure 9 illustrates the amount of power density radiated from the tower and how humans are exposed to this radiation in this residential area. This amount of radiated power needs about 300 meters to fade away as seen in Figure 9 which means that most of the citizens living within this area are at risk.

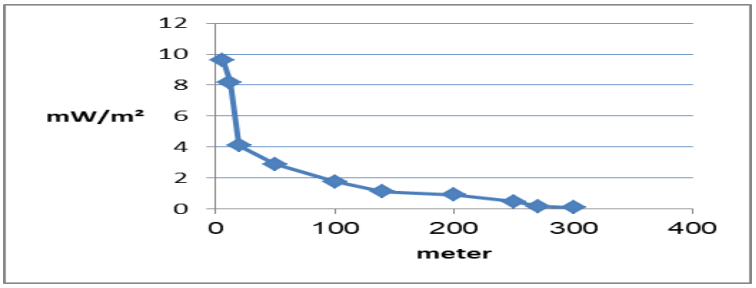

Figure 9. Fading of the power density radiated from the tower

5. Conclusion

The aim of the current paper is to measure the amount of radiation that is radiated from cell phone towers in Mosul city that are exposed to humans and compared it to international safety standards. The measured showed that the RF radiation levels from the cell phone towers in Mosul city were much higher than the permissible exposure limit and the safe limits set by international standard organizations. These measurements could be interpreted that the city is exposed to high amounts of radiated power density which means that the city is in a risky situation and the majority of the city's population is normally exposed to significant levels of RF radiation in their ambient environment. The high RF radiation penetrates living tissue and it reaches up to 1 centimeter at the frequencies that are

used in cell phones. These radio rays interact with the tissues of the body and the body temperature rises when it absorbs this radiation energy but the natural thermal equilibrium processes in the body transfer this energy to the outside. Scientists have published reports of other effects of prolonged exposure to high radio frequencies, including changes in brain activities, the speed of reactions, as well as the effect on sleep patterns. The presence of high radiated power in certain places may interfere with some electronic devices used for health purposes, especially in intensive care centers in hospitals, and also near airports because it may interfere with air navigation electronic equipment. This risk may be underestimated by following up on the next suggestions according to the World Health Organization (WHO):

1. Children must spend most of their time in level 1 of Table 3. They may spend Short periods of time in levels 2, 3and 4.
2. Pregnant women must spend most of their time in level 1 of the table 3, brief visits to levels 2 and 3 will probably not be harmful, but level 4 must be avoided.
3. All citizens must avoid continuous prolonged exposure at level 4 of Table 3.
4. All houses, hospitals, workplaces, schools, and libraries must be at level 1 of Table 3.

There is a need to use barriers or other protective shields at cell phone towers (especially those installed on the roofs of buildings) in order to prevent and reduce entry of EMF radiation to places where the permissible exposure limits may be exceeded.

Finally, tower locations should provide good coverage for broadcasting, to be easily accessible for maintenance work, and radiation levels around cell phone towers do not pose a health hazard. It should be taken into account the aesthetic aspects and sensitivity of the audience and may need to take special consideration when deciding to erect cell phone towers near nurseries, schools, hospitals, and playgrounds. The open dialogue and communication between the companies operating the towers and the local councils as well as the public in the planning stages of the installation are very important and essential. Also, an effective system of health information and communication between scientists and the government must be established as well. This will raise the level of public awareness about mobile technologies and dispel any doubts or fears. This information must be correct and appropriate to the level of readers or listeners.

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