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Comparative Study of Radiofrequency Radiations from GSM Base Stations in Residential Areas

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Abstract: ***As technology progresses and data demands have increased on mobile network, towns and cities have seen a number of towers increase sharply. Installation of base station antennas has produced concerns about health and in some cases has resulted in litigation in court. Independent researches and measurements on electromagnetic fields in areas close to base stations was discussed in many countries, as well as a comparison of the level of exposure of local populations and current exposure limits. Two of the most important factors in these measurements are the distance and the direct line of sight to the antenna site. The objectives of this study are to determine the level of radiofrequency radiation around GSM base stations located in residential area. In this study, measurements have been carried out at various places near the cell towers inside residential areas in Kirkuk-Iraq. It has been found that the radiation levels were above the recommended values. The results of this study show that the amount of power density is more than ten times greater than the recommended safety power density. Comparison between measured power densities in different countries has been made also.***

Keywords**-Cell towers radiation levels, GSM base stations, Safety power density.**

I. INTRODUCTION

Over the last decades wireless technologies have gained in importance. As a result, however, TV and radio stations are no longer the broadcasting sources that cause the highest exposure levels in residential areas; now it is cell phone base stations. Worldwide, the use of mobile telephony has increased considerably with the introduction of the digital GSM 900 systems in the 1990s [1-3]. Due to the growing of these systems and the explosive growth in the multitude of base stations to meet required efficiency from the networks, there iscurrently an increasing concern about the effects of electromagnetic exposure in the microwave rangeand radiofrequency (RF) radiation on exposedorganisms and humans [4]. Further as the costs of mobile technology have fallen, their uses have increased dramatically and the overall levels of exposure of the population as a whole have increased drastically. With increase in cell phone communication, number of cell towers getting installed is increasing every day. This increased use of mobile phones has led to an important deployment of base stations. The number of base stations in any country depends on several factors as the number of network providers, the number of users and the topography [5]. In Kirkuk-Iraq, currently there are hundreds of cell phone towers, and to meet the communication demand, the number will increase rapidly. Such base stations are often situated close to dwellings or houses and have become the reason for concerns of parts of the population in the recent years. Some of the base stations are planted right in a home of residence. The concerned population often wants to know the level of exposure due to the base stations, if these levels of exposure might be health relevant and if the levels comply with national and international standards, guidelines and regulations. To answer these questions, local and national authorities network providers and private persons often contract qualified institutions to evaluate the exposure level in restricted areas. A base station and its transmitting power are designed in such a way that mobile phone should be able to transmit and receive enough signal for proper communication up to a few kilometers. These cell towers transmit radiation 24x7, so people living within 10's of meters from the tower will receive 10,000 times stronger signal than required for mobile communication [6]. Majority of these towers are mounted near the residential and office buildings to provide good mobile phone coverage to the users.In cities, millions of people reside within these high radiation zones. The cellular base stations are transmitting continuously even when nobody is using the phone. We know from a variety of scientific studies, that significant biological effects result from the non-thermal effects of extremely periodic -pulsed - HF-radiation as are utilized in the most common modern digital cellular and cordless phone systems round the world. Not all standards and guidelines throughout the world have recommended the same limits for exposure. For example, some published exposure limits in Russia and some eastern European countries have been generally more restrictive than existing or proposed recommendations for exposure developed in North America and other parts of Europe.Very limited information is available on the exposure to cellular base station radiation in residential areas at different distances and directions to antenna sites [7, 8].

II. RADIATIONFROM THE CELL TOWER

A GSM900 base station antenna transmits in the frequency range of 935 - 960 MHz. This frequency band of 25 MHz is divided into twenty sub-bands of 1.2 MHz, which are allocated to various operators [9]. There may be several carrier frequencies (1 to 5) allotted to one operator with upper limit of 6.2 MHz bandwidth. Each carrier frequency may transmit 10 to 20W of power. So, one operator may transmit 50 to 100W of power and there

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may be 3-4 operators on the same roof top or tower, thereby total transmitted power may be 200 to 400W [10]. In addition, directional antennas are used, which typically may have a gain of around 17 dB (numeric value is 50), so effectively, several KW of power may be transmitted in the main beam direction.Radiated power density can be calculated for N number of base stations at distances $R_n$using [11]:

$$P_d = \sum[(P_{tn}G_{tn})/(4\pi R_n^2)] \quad (1)$$

where, $N \geq n \geq 1$,
P_{tn} = Transmitter power in Watts from n^{th} station.
G_{tn} = Gain of transmitting antenna of nth station.
R_n = Distance from the antenna n^{th} station.
The simplest case is the one when a human is exposed to a single base station antenna (N=1), as shown in the Figure (1), [12].

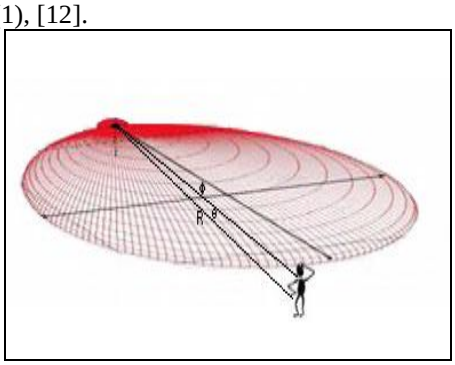

Fig (1): Human exposed to a single base station antenna.

Following the above computational steps, the power density for the frequency 945 MHz, using equations 1 were computed. Table (1) gives the power density for Pt = 20 W, Gt = 17 dB (Gt = 50.12), for various distances from the transmitting tower.The power density values given in Table-1 are for a single carrier and a single operator, (N=1). If multiple carriers are being used and multiple operators are present on the same roof top or tower, then the values will increase many times. However, radiation density will be much lower in the direction away from the main beam. One should know actual radiation pattern of the antenna (which unfortunately is not made public) to calculate exact radiation density at a point.

Table (1): Power density and received power at various distances from the transmitting tower

R in m	P_d in mW/m^2	P_d in dB_m
1	79766.43	49.018
2	19941.60	42.998
3	8862.94	39.476
4	4985.40	36.977
5	3190.66	35.039
6	2215.73	33.455
7	1627.89	32.116
8	1246.35	30.956
9	984.77	29.933
10	797.66	29.018
20	199.42	22.998
30	88.63	19.476
40	49.85	16.977
50	31.91	15.039
100	7.977	9.018
200	1.994	2.997
300	0.886	-0.526
400	0.499	-3.019
500	0.319	-4.962

Fig (2) shows the graph of power density versus distance for a typical base station.

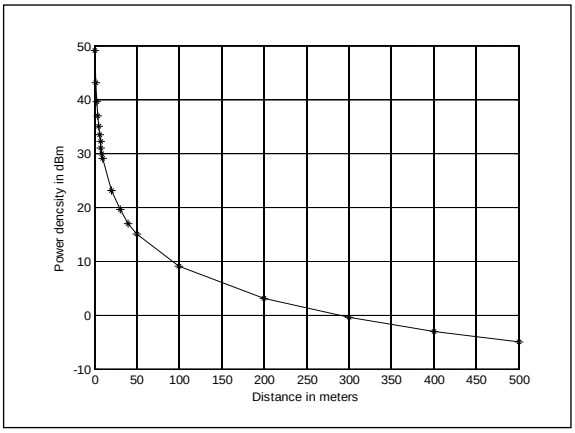

Fig (2): power density versus distance.

III. MEASUREMENT OF RADIO FREQUENCY RADIATION FROM GSM BASE STATIONS

The base station antennas in the selected sites were the more common panel antennas, which divide the area around the base station into three sectors. With this arrangement of the three antennas the entire region around the base stations were covered. The signals radiated are for digital mobile telephone systems that operate with GSM frequency band of 900 MHz. Total exposures due to frequency range for mobile phone base stations were measured with the aid of a 3 Axis Radio Frequency Electromagnetic Field Tester (Model: EMF-839) [13]. This equipment is specially developed for measuring or monitoring electromagnetic field, for example: cell-phone stations. It is used for broadband devices of monitoring the wide range radio frequency electromagnetic field value, which allows each received radio signal, in the range of 100 KHz to 3 GHz.

IV. RADIATION MEASUREMENTS

For the purpose of this research, one major service provider in Kirkuk is selected, that provided GSM coverage to all the regions under consideration. The major concern was the radiation emitted by base station antennas, considering stations that are sited within 50m from residential buildings, and densely populated areas. Measurements of the base station signals conducted from 9:00 AM to 2:00 PM local time in Kirkuk. The power radiated by base stations is highly dependent on the number of subscribers making calls at the same time.

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Thus, the measured radiated power depends on time, place, direction, distance of measurement and season. For hot countries or hot seasons in countries, the acceptable maximum radiated power density should be much lower. The number of sites taken in this research work were 5 sitesin Kirkuk - Iraq.The measurements were taken at distances about 50 meters around the base stations, as shown in Figures (3-7).

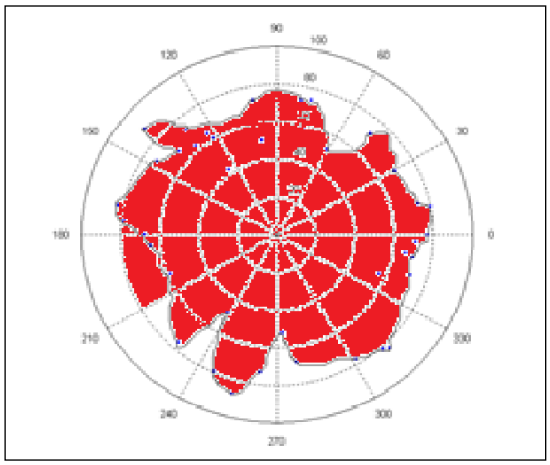

Fig (3): Power density around a base station in site (1).

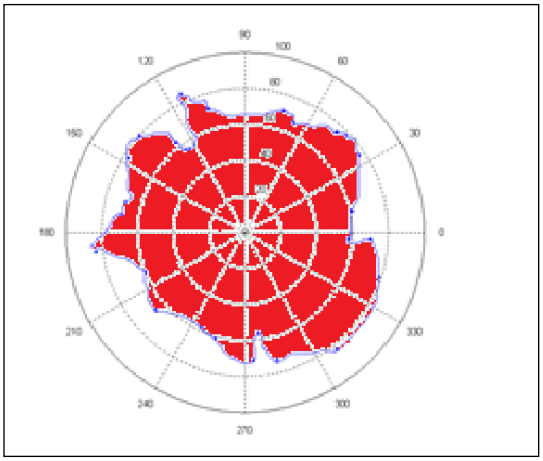

Fig (4): Power density around a base station in site (2).

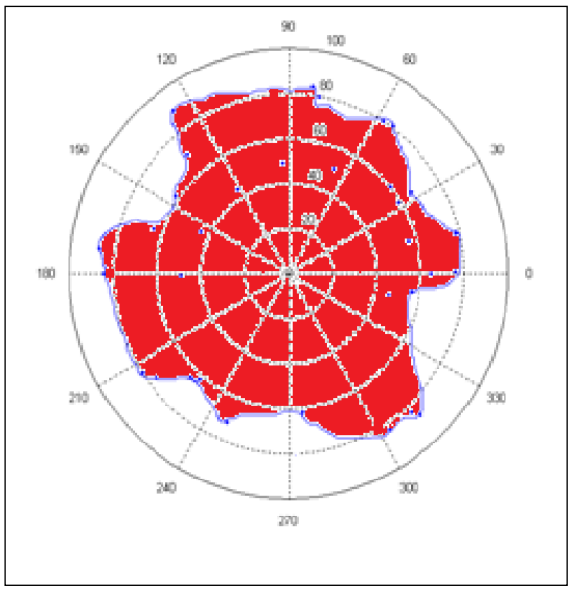

Fig (5): Power density around a base station in site (3).

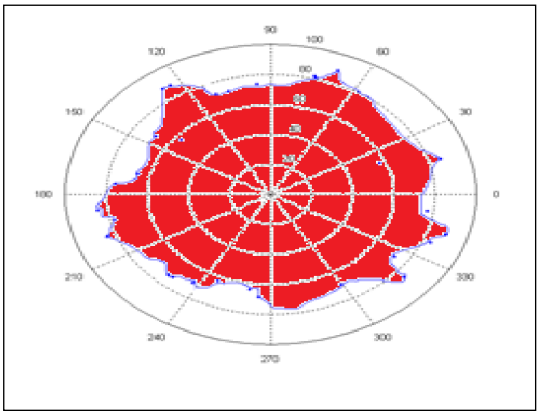

Fig (6): Power density around a base station in site (4).

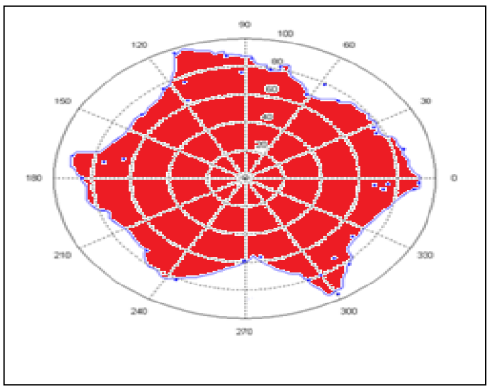

Fig (7): Power density around a base station in site (5).

The average power density was 71.226 mW/m^2, which is more than twice of theoretically calculated power density, (as shown in table (1)), using equation (1). Figure (8) shows the comparison between measured power density in different countries [14- 23] with safety code 6 given by equation (2), [24].

$$P_d = f/150 \qquad (2)$$

Where f is the frequency (MHz), in the range of (300-1500 MHz). So thecalculated maximum safety power density is equal to (6.3 mW/m^2).

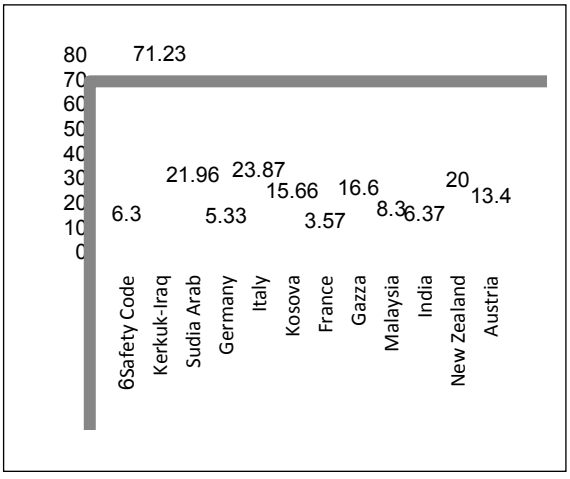

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Fig. (8) Comparison between measured power densities in different countries.

V. CONCLUSION

In this study, the level of radiofrequency radiations emitted by the transmitters at the base station located around the residential areas have been carried out at various places at distances about 50m away from the cell towers in Kirkuk-Iraq. Five sites have been taken at different directions. The results of this study show that the average power density in more than 90% of the measures was 71.226 mW/m^2. This amount of power density is more than ten times greater than the recommended safety power density which is equal to or less than 6.3 mW/m^2. Comparison between the power density in many countries shows that the minimum measured power density was in France then Germany and India, and the worst is in Iraq. Therefore, many comprehensive studies are necessary to be done in this country, to protect peoples from the risk of the exposure to this high power density of the radiation of cells phone tower especially in residential areas. This comparative analysis of the results of RF exposure surveys of mobile communications networks has a number of limitations. Caution must be observed in comparing absolute values between countries because of differing measurement instruments, the criteria for selecting the measurement locations was not standardized between countries, settings of measurement equipment and survey methodology. Development of uniform guidance based on technical measurement standards would improve comparability of the results.

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