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Measurements of Electromagnetic Fields Emitted from Cellular Base Stations in Shirqat City

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Abstract

With increasing the usage of mobile communication devices and internet network information, the entry of private telecommunications companies in Iraq has been started since 2003. These companies began to build up cellular towers to accomplish the telecommunication works but they ignore the safety conditions imposed for the health and environment that are considered in random way. These negative health effects which may cause a health risk for life beings and environment pollution. The aim of this work is to determine the safe and unsafe ranges and discuss damage caused by radiation emitted from Asia cell base stations in Shirqat city and discuses the best ways in which can be minimize its exposure level to avoid its negative health effects. Practical measurements of power density around base stations has been accomplished by using a radiation survey meter type (Radio frequency EMF Strength Meter 480846) in two ways. The first way of measurements has been accomplished at a height of 2 meters above ground for different distances from (0-300) meters .The second way is at a distance of 150 meters for different levels from (2-15) meters above ground level. The maximum measured power density is about (3) mW/m^2. Results indicate that the levels of power density are far below the RF radiation exposure of USSR safety standards levels. And that means these cellular base station don't cause negative the health effect for life being if the exposure is within the acceptable international standard levels.

Key words: Cellular Mobil Base Stations, Asia cell, EMF strength meter, RF radiation exposure.

قياس المجال الكهرومغناطيسي المنبعث من محطات الهاتف النقال في مدينة الشرقاط

الخلاصة

مع ازدياد استخدام أجهزة اتصال الهاتف النقال وشبكة معلومات الانترنيت بدأ دخول شركات الاتصال الخاصة إلى العراق بعد العام 2003 . هذه الشركات بدأت بنصب أبراج لتامين عملها بطريقة عشوائية وبشكل أهملت فيه مراعاة الشروط التي تفرضها السلامة الصحية والبيئية. مما قد يسبب أضرارا صحية وبيئية تهدد الكائنات الحية. إن الهدف من هذا البحث هو تحديد المسافات الآمنة والمسافات الغير آمنة التي تسببها الأشعة المنبعثة من محطات الاتصال لشركة آسيا سيل في مدينة الشرقاط والتعرف على مستوى الإشعاع ومحاولة تجنب وتقليل الآثار السلبية لذلك الإشعاع . أنجز البحث بقياس عملي لكثافة القدرة قرب محطات الاتصال الخلوي (بواسطة جهاز قياس شدة الإشعاع الكهرومغناطيسي ذي الترددات العالية موديل 480846) بطريقتين: الطريقة الأولى اعتمدت ارتفاع ثابت وهو (2) متر فوق سطح الأرض والمسافة متغيره من صفر إلى(300) متر.والطريقة الثانية للقياس اعتمدت المسافة

ثابتة وهي (150) متر والارتفاع متغير من 2 إلى 15 متر وقد بلغت أعلى كثافة قدره (3) ملي واطا متر مربع. أظهرت النتائج أن كل مستويات قياس كثافة القدرة كانت أدنى وبعيدة عن المستويات المعتمدة حاليا في جمهورية روسيا الاتحادية. هذا يعني انه لا خطر على الكائنات الحية إذا لم يتجاوز الإشعاع من هذه المحطات المستوى المسموح عالميا.

الكلمات الدالة: محطات الاتصال الخلوي، أبراج شركة آسيا سيل، جهاز قياس شدة الإشعاع الكهرومغناطيسي، الضرر من إشعاع الترددات الراديوية.

List of Abbreviations

(EMF): electromagnetic field.
(EMR): electromagnetic radiation.
(RF) : radio frequency.
(Who): world health organization.
(ICNIRP):.International Commission on Non-Ionizing Radiation Protection.
(FCC) :Federal Communications Commission.
(IRPA):International Radiation Prote-ction Association.
(ARPANSA): Australian Radiation .
(PCS): personal communications systems.
(ERP): effective radiated power.
(GSM) : acronym for Global System for Mobile.
(BTS) :transceiver station .
(PCN) :personal communications network.
(BSC). : base station controller.
(EIRP):effective isotropic radiated Power Protection and Nuclear Safety Agency
(RTs) : radio terminals.

Introduction

The last years have seen rapid growth in the use of RF and microwave frequencies, particularly in communications (mobile communications systems monitoring, telecommunications satellites, etc.) With this increased mobile phone use (and accompanying growth of mobile phone base stations), the public concern on potential harmful effects of

every day exposure to radio frequency (RF) electromagnetic fields (EMF) has also increased, as these fields are emitted by mobile phones and other wireless communication device. The RF-EMF emitted by mobile phones is absorbed through the skull to some extent, and the brain is exposed to this radiation [1]. The possible health effects resulting from the exposure to low-level RF fields from communications antennas have received continuing interest and are subject to a great deal of controversy [2].

There are a number of national and international regulations, standards and recommendations dealing with electromagnetic exposure in the radio frequency range. The limits are generally very similar and are usually based on recommendations from the World Health Organization (WHO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Federal Communication Commission (FCC), the International Radiation Protection Association (IRPA), and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) [3-10]. Based on established scientific studies, it is claimed that the limits have been set with a wide margin in order to protect people from any known negative health effects of both short- and long-term exposure to electromagnetic fields. Basic restrictions on exposure are provided for both general public and workers exposed in the workplace. Occupational exposure limits are generally less restrictive than non occupational since some control can be applied over the condition and duration of exposure. as shown in table (1) and figure (1) .

Cellular mobile systems can be divided into three generation ,the first operates in the (450 or 900)MHz band , the second is digital generation operates in the 900 MHz, 1800 MHz or 1900 MHz band and the third generation in the 2000 MHz band. In Republic of Iraq, Asia cell mobile systems operates on the frequency range of (903.4-915)MHz uplink to (948.4-960)MHz downlink with bandwidth of (11.6 MHz) that means it works in second generation (GSM900).

This work presents the results of electromagnetic power density measurements in the surrounding area of cellular base stations as a function of distance from the antenna and the height level above the ground. The base stations are chosen at different locations in Shirqat city which is a part of Salah-aldin province, republic of Iraq to determine the safe and unsafe ranges from the cellular base stations an compare these results with the RF radiation exposure of USSR safety standards level.

Practical measurements

The GSM network in Shirqat city divides the city into macro cells radio base stations. The base station system consist of a base transceiver station (BTS) and a base station controller (BSC). The transmitting antennas of the base stations are usually installed on the top of either a lattice type tower at a height of (25-48) m or the roof-top of a building typically at a height of (35-39) m. The antenna system is arranged in three groups at different angles to the azimuth. One antenna in each sector is utilized for the downlink (BTS to mobile) and the other two are used for receiving signals from the mobile.

Each group consists of three linearly polarized high gain rectangular antennas which are approximately 2.3 m long and 0.3 m wide with a total down tilt of 5~10º to the vertical so that the field strength at ground level depends on the characteristics of the antenna. The main beam is slightly tilted downwards as shown in figure (2). But does not reach ground level until the distance from the tower is at least 50 m (usually 50–200 m).In case of free sight to the antenna, maximum field strength is reached to that distance[11].

The measurements have been conducted in two ways:

- in the first way ,the EMF radiations from mobile base station at a height of 2 meters above the ground level at different distances 0 to 300 meters have been measured and results are shown in table(2).

From the measurements of the two towers Asia cell (1) and Asia cell (2) (which at a height of 50m) ,we can see that the maximum power density are (0.48-0.88) mW/m^2 respectively . While the measurement of towers with small height such as Asia cell (3) and Asia cell (4) (which at a height of 35m) , the maximum power density are (1.8-3)mW/m^2 .That mean as more the tower is higher, the risks is lower .so we can conclude that all the measurements didn't exceed the standard exposure levels.

The second way of measurements s is with constant distance of 150 meters at different levels above ground from (2-15 m). In table (3) we can see that the strength of power density increased with increasing the height of measuring level. We were obtained the measurements at different heights by climbing the adjacent hills for each height (5,8,10,12 and 15 m) and we had the highest value ($3mW/m^2$) at a height of (12m).

The comparison results of measurements with the international standard exposure levels indicate that theses measurements are far below the Maximum Permissible Exposure Limits (MPEL) [3-10].

Figure(3) shows Asia cell company base stations which are distributed in different areas of Shirqat city . From the map, it is clear that the Base Station Asia cell (1) and Asia cell (2) are in the inside the city area and is closer to downtown but with some low-height and high-density buildings and some fairly open areas. The other two base stations Asia Cell (3) and Asia Cell (4) are located in an areas where adjacent to the hills which are relatively higher . The transmitting antenna of base Station Asia cell(4) is installed on the rooftop of a double level house .The measurements in this area is higher because of the low height of towers and the effect of the reflections of radiation from hills .

The measurements are carried out using a radiation survey meter model Radio frequency EMF Strength Meter 480846 as shown in figure (4).The EMF Strength Meter 480846 has the following characteristics:

1. Frequency range 10 MHz to 8GHz (optimized for 900 MHz, 1800 MHz, 2.7 GHz , 3.5 GHz and 8 GHz).
2. Measuring range $20mv/m^2$ to $108v/m^2$, 53 μA/m to 286.4mA/m, $1μW/m^2$ to $30.93W/m^2$, $1μW/m^2$ to $30.93 W/m^2$, $0μW/cm^2$ to$3.093 mW/cm^2$.
3. Resolution $0.1mv/m^2$, $0.1μA/m^2$, $1μW/m^2$,$0.001μW/cm^2$.
4. Recording maximum and average power densities measurement.

Results and Discussions

Theoretically, the calculation of the power density (Pd) at a distance of (d) meters from any antenna radiates a power of Pt with a gain of Gt is given by the following equation:[11]

$$P_d = (P_t * G_t / 4 \pi d^2) \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Where :

P_t : Transmitter power in watt .

G_t : Gain of transmitting antenna .

d : Distance from the antenna in meters .

Practically, the variation of the measurements of average power density *Sav* and maximum power density *Smx* with 2m height above ground at a difference distances d from the base station of Asia cell towers (1,2,3 and 4) are illustrated in the figures (5,6,7 and 8) respectively.

Fig.(5) shows results of measurements of *Sav* and *Smx* of electric field versus distance in meters from the tower of base station Asia cell (1). This figure shows that *the Smx* increases from 60 $μW/m^2$ at the base of the tower to 450 $μW/m^2$ at a distance of 150m and a height of 2 m above the ground. It is shown that the power is direction-dependent relative to the base station antennas.

Figure (6) shows that the power density increases with the increasing of distance from the tower; from zero to 180 $μW/m^2$ at a distance of 50 m. Then the power density starts fluctuating around 800 $μW/m^2$ as the distance (150-200) m. The fluctuation may be attributed to the effect of multipath propagation from the transmitting antenna on the tower to the receiving probe. After distance of 200m *Smx* starts to decrease to reach the distance of 300 meters. So it still within the allowed limited standard (10µW/cm^2).

Figure (7) shows results of measurements of the *Sav* and *Smx* from the tower of base station Asia cell 3. This figure shows that *Smx* increases from about 0.06mW/m^2 at the base of the tower to about 1.8mW/m^2 at a distance of about 150m from the tower and at a height of 2 m above the ground level. Then, it starts to decrease until the distance increases beyond (200) m where *Smx* starts to fluctuate. Also the measurements did not exceed allowed limited standard of 10µW/cm^2.

The variation of maximum and average power density versus the distance from the tower of base Station Asia cell (4) is shown in Fig.8. In this case, the antennas are installed on a total height of 38 m.

Figure (8) shows that, the power density at first the measurement remains constant ;less than 0.12mW/m^2 until reaching the distance of 100m then EMF radiation start rapidly increasing until reaching the highest value of about 3mW/m^2 at distance of 150m .Then the power density start to decrease at a distance of (200-300)m . However, again the measurements are far below the USSR standard of the power density which is evident in the figure .The increasing in measurements because of environment area of the tower place and also due to the effect of the presence of hills and building on EMF radiation caused from multiple reflection.

- Fig. (9) and 10 shows the variation of *Sav* and *Smx* (mW/m^2) with height *h*(m) above the ground and at a distance *d* = 150 m from the base of the tower. The maximum power density may reach (3) mW/m^2 at a height of 15 m above the ground; and 150 m distance from the base of the tower. As shown in Figure(9 and 10), a linear model can represent the increasing of power density (in mW/m^2) with height increase *h* (in meters), namely, at *d* = 150 m as[12] :

$$Smx(\mu W/m^2) = 0.73 h m)-0.47 \quad \ldots\ldots(2)$$

$$Sav\ (\mu W/m^2) = 0.44\ h\ (m) - 0.1 \quad \ldots\ldots(3)$$

From measurements we can conclude that the RF field intensity at the ground level directly below the antenna is low. The RF field intensity increases slightly as one moves away from the base station and then decreases at greater distances from the antenna.. Because of the narrow vertical spread of the beam.

Conclusions

The RF radiation from the antennas of base stations of Asiacell cellular mobile radio system in Iraq operating in second generation(GSM-900) has been evaluated. The study base stations were randomly chosen at different locations in city of Shirqat.

The measurement results show that the maximum power density at a distance of 150m at 2m height above the ground level is about 3mW/m^2. The variation of power density in a height of (2-15m) above the ground level is linear. This maximum measured power density is far below the maximum permissible exposure limits of most of the well-known RF safety standards which ranges from (10-100) µW/cm^2. .

Generally, we can conclude that for all the Asia cell base stations, it is found that the power densities are relatively low at the foot of base station tower ($d \leq$ 50 m), where it is $\leq$ 0.06 mW/ m^2, and increases with increasing the distance from the tower. This is in agreement with the measurements by Peterson Testagrossa[13]. The maximum measured power density at a distance of (150) m from the base stations, at (2m) height above the ground, is about (1.5) mW/m^2. But it increases with the increasing of height to about 3mW/m^2 at (12) m above the ground at (150) m distance from the tower. In general, this measured power density is far below the Maximum Permissible Exposure Limits (MPEL) of the standards and guidelines for public exposure. It is about 0.65% of the FCC or the ANSI/IEEE or the Japanese standards, 0.87% of the CENELEC or IRPA or Finnish standards, and about 3% of the Russian standard[3-10].

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Department of electrical Engineering in Tikrit University is acknowledged for supporting of this work through providing the EMF tester. Local government in the district of Shirqat which gave us permission to enter and measure in all Asia cell base station in Shirqat is acknowledged too. The author would like to thank Prof.Subhi Al-Rawi for assisting in accomplishing this work.

Recommendations

- Establishment of a specialized national organization from the Ministry of Higher Education and Scientific Research and the Ministry of Health and the Environment Statement to monitor Raised the communications towers effect on the health of the human public to control Communications towers when erected by mobile phone companies and improve the environment of Iraq
- The communication towers must be far away from a large population with distance not less than 300m specially from schools and kindergartens to avoid its negative health effects.
- Open communication and discussion between the mobile phone operator, local council and the public during the planning stages for a new antenna can help create public understanding and greater acceptance of a new facility. This information should be accurate, and at the same time be appropriate in its level of discussion and understandable to the intended audience.

References

1-Wiart J, Hadjem A, Wong MF, Bloch I. Analysis of RF exposure in the head tissues of children and adults. Physics in Medicine and Biology. 2008;53:3681-3695

2- Foster, R.K., Erdreich, L.S. and Moulder, J.E., .Weak Electromagnetic Fields and Cancer in the Context of Risk Assessment., Proceedings IEEE, vol. 85, No. 5, pp. 733-746, 1997.

3-. World Health Organization: www. who.int/peh-emf

4-. International Commission on Non-Ionizing Radiation Protection: www. icnirp.de

5- Federal Communication Commission: www.fcc.gov

6- Australian Radiation Protection and Nuclear Safety Agency: www.arpansa-.gov.au

7- ANSI/IEEE C95.1-1992, Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz., , IEEE, New York, USA.

8- CENELEC, .Human Exposure to Electromagnetic Fields. High Frequency (10 kHz to 300 GHz)", ENV 50166-2, Jan. 1995.

9- USSR , ministry of Health, Central Health and Epidemiological Administration, Interim Health Standards and Regulations on

Protecting the General Population from the Effects of the Electromagnetic Fields Generated by Radio transmitting Equipment, 1984.

10- Kari, J., .Finnish Exposure Standards., SSI-rapport 89-15, Second Nordic Meeting on Non- ionizing Radiation, 1981.

11- prof. Girish Kumer Radiation Hazard from Cell Phonees/Cell Towers Electrical Engineering Department dt Bombay Powai Mumba , 2010.

12- Dr. AL-RUWAIS ABDULAZIZ S., Electromagnetic Field Measurements near Macrocellular Base Stations, JKAU: Eng. Sci., vol. 13 no. 1, 2001

13- Peterson, R.C. and Testagrossa, P.A., .Radio-frequency Electromagnetic Fields Associated with Cellular-radio Cell-site Antennas., *Bioelectromagnetics*, Vol. 13, pp. 527-542, 1992.

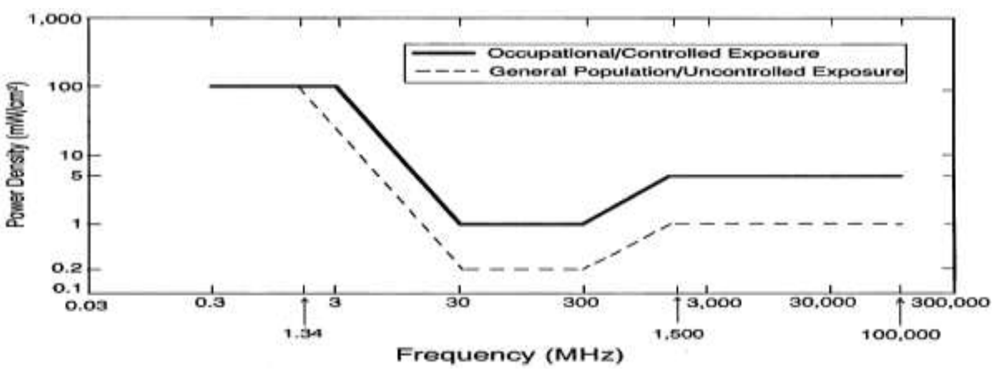

Figure.(1): Graphical representation of exposure limit for general public

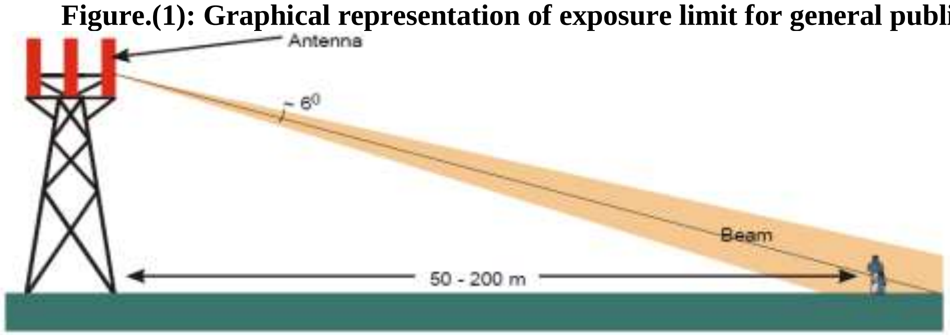

Figure.(2) : Elevation showing the shape of beam formed by a typical antenna used with cellular base station.

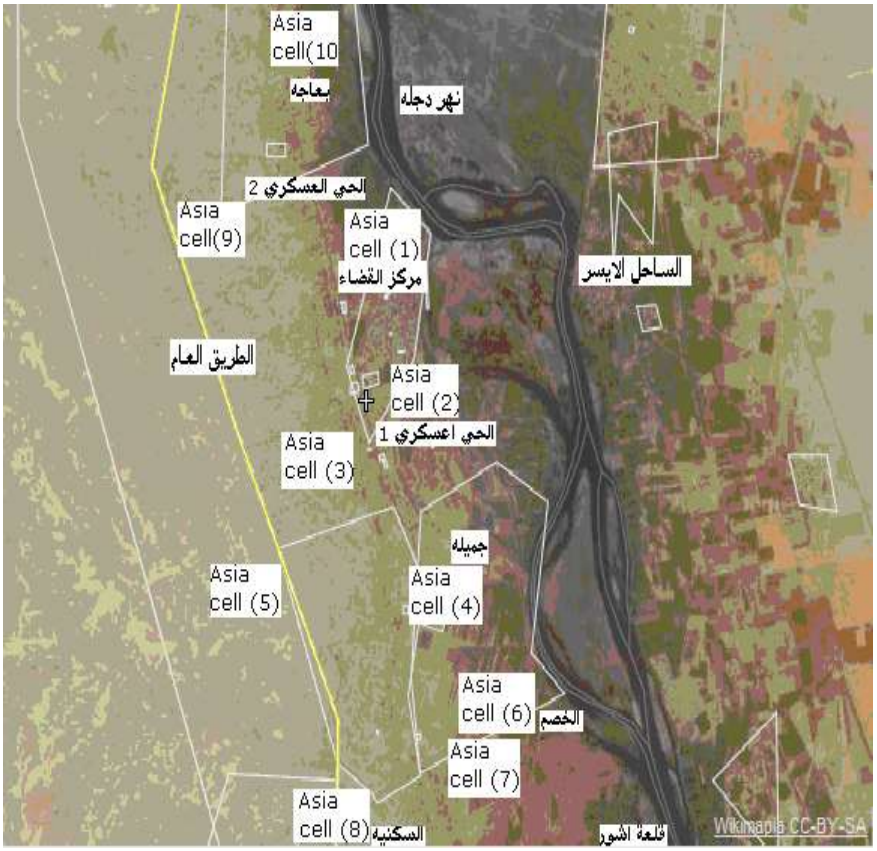

Figure.(3) : Distribution of the Asia cell base stations in Shirqat city.

Figure.(4) : RF EMF strength meter 480846

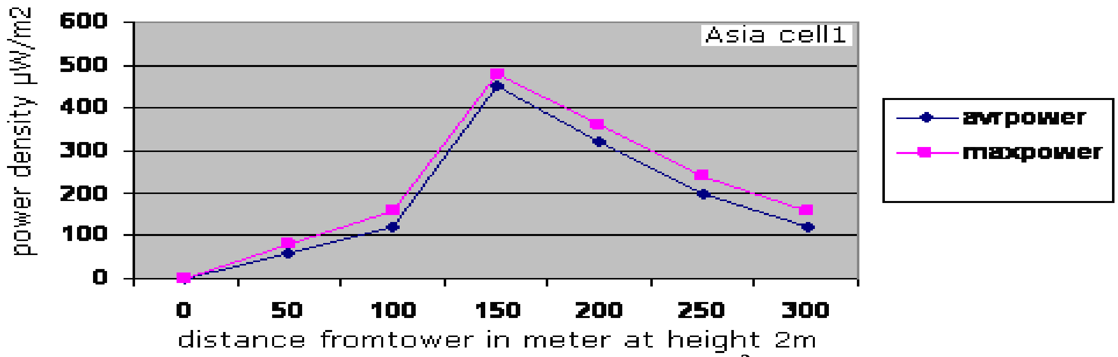

Figure. (5): shows the variation of *Sav* and *Smx* (µW/m^2) with height 2m above the ground and at a difference distances from the base of the tower (1) .

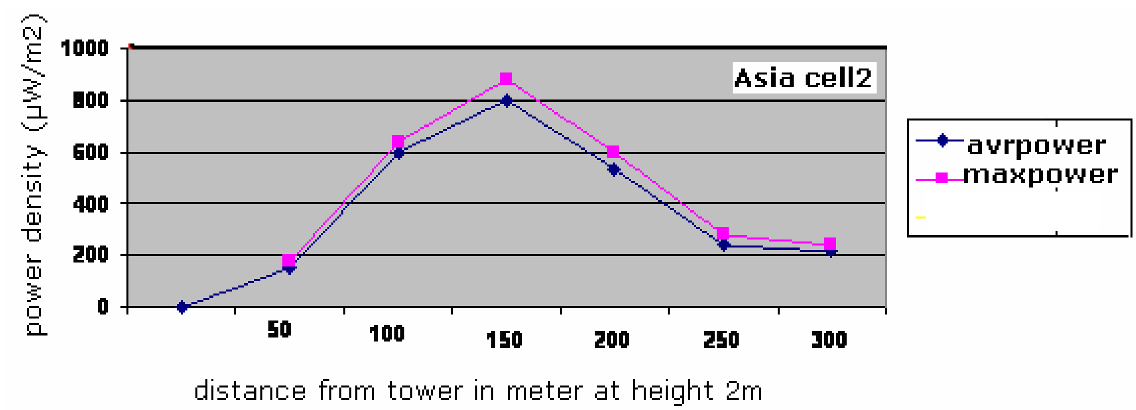

Figure (6): shows the variation of the power density *Sav* (µW/m^2) with distance *d* (dm) from the tower of base Station Asia cell(2).

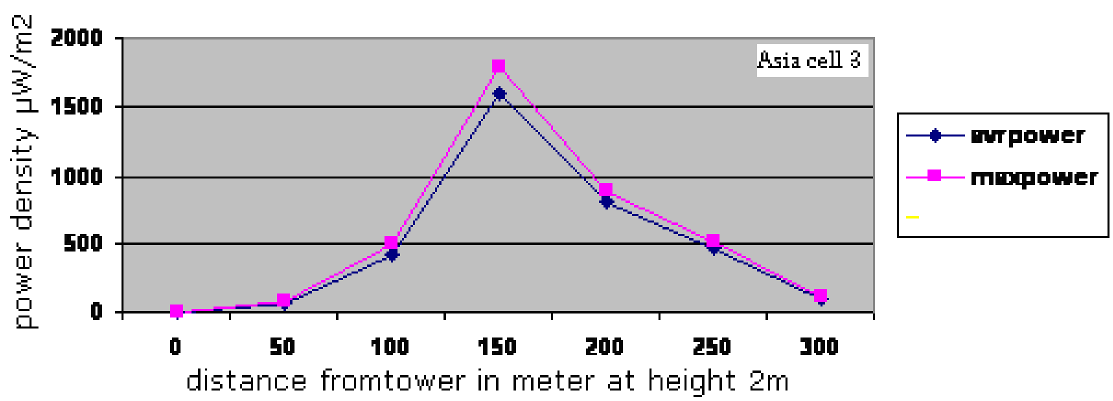

Figure.(7): shows the results of the maximum and average power density versus distance *d* from the tower of base Station Asiacell(3).

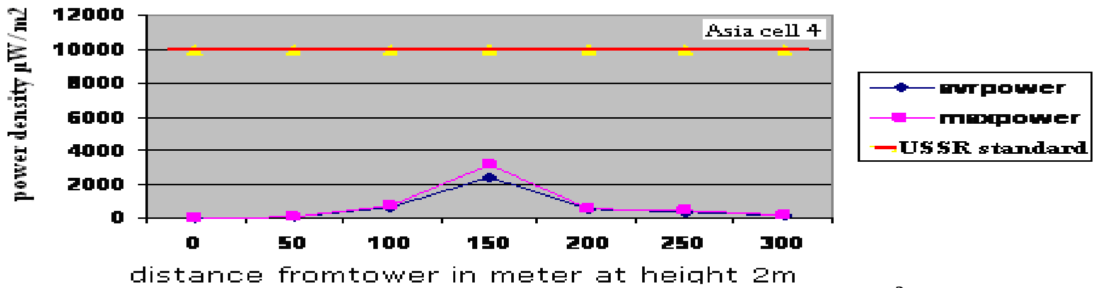

Figure.(8): Variation of maximum and average power density *Sav* (µW/m^2) with distance *d* (m) from of base Station Asia cell (4).

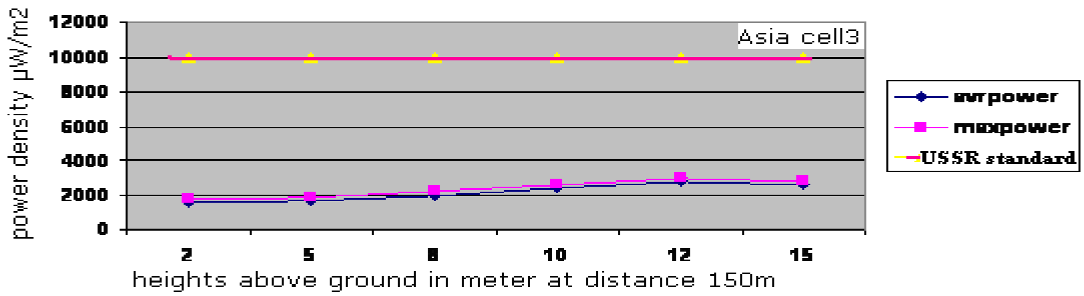

Figure.(9): Fitting the variation of maximum and average power densities, *Smx* and *Sav*, with height above the ground *h* (m), to a linear model at distance *d* = 150 from Asia cell (3).

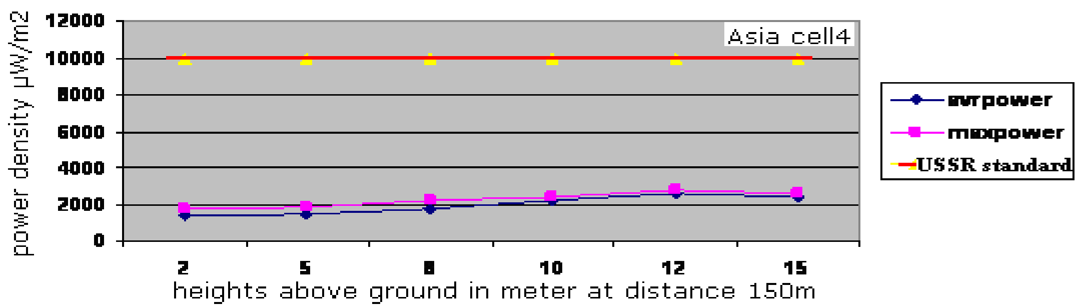

Figure.(10): Fitting the variation of maximum and average power densities, *Smx* and *Sav*, with height above the ground *h* (m), to a linear model at distance, *d* = 150 from Asia cell (4).

Table (1): Limits for electromagnetic fields exposure emitted from cellular base stations[3-10].

Frequency range(MHz)	Electric field strength(V/m)	Magnetic field strength(A/m)	Power density (S),(mW/cm^2)	Average time $(E)^2$, $(H)^2$,S
0.3 – 3.0	614	1.63	(100)*	6
3.0 – 30	1842/f	4.89/f	(900/$f^{2)}$*	6
30 -300	0.16		1.0	6
300 -1500	---		f/300	6
1500 -100.000	---		5	6

frequency in MHz *plane wave equivalent power density

Table (2) : EMF measurements of chosen Asia cell base station in Shirqat city at a height of 2m.

Site name	Tower (m)	max and average Power density in μW/m^2 for each following distance at height of 2m						
		0	**50m**	**100m**	**150m**	**200m**	**250m**	**300 m**
Asia cell 1	50	0	60 80	120 160	450 480	320 360	200 240	120 160
Asia cell 2	48	0	150 180	600 640	800 880	540 600	240 280	220 240
Asia cell 3	38	0	60 80	420 500	1600 1800	800 880	460 520	100 120
Asia cell 4	35	0	80 100	650 700	2400 3000	540 600	380 480	180 220
Asia cell 5	35	0	80 150	240 260	600 650	460 480	180 220	80 120
Asia cell 6	25	0	100 140	150 180	500 540	320 350	140 180	60 80

Table (3) : EMF Measurements of chosen Asia cell base station in Shirqat city in distance 150m at height (2-15)m .

Name site	max and average Power density(mw/m^2) at distance 150 m from the tower at following height					
	2m	**5m**	**8m**	**10m**	**12m**	**15m**
Asia cell 3	1.6 1.8	1.7 1.9	2 2.2	2.4 2.6	2.8 3	2.6 2.8
Asia cell 4	1.4 1.8	1.6 1.9	1.8 2.2	2.2 2.4	2.6 2.8	2.4 2.6