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A study of the levels of radiation power emitted by internet network towers in selected areas of Mosul City

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Abstract--The aim of this study is to evaluate the energy density levels of internet network towers in Mosul city that operate in the 5 GHz frequency band, and then compare the observed energy density levels to national and international standards for radiation protection. In this study, the HF-B8G instrument used to measure the energy density of electromagnetic radiation. The data collected from Internet network towers from both the right and left sides of Mosul city, with the towers' locations determined using the Global Positioning System (GPS). The results of field researches showed that radiofrequency radiation levels are significantly lower than the nationally and globally allowed limits. The highest average power density (PD) within the frequency band (5GH) for the left and right sides of Mosul, respectively, was 0.005362W/m² and 0.003516W/m², while the highest recorded value for max power density was 0.00848W/m² on the left side and 0.007045W/m² on the right side of the city. The radiation power values recorded at distances of 10, 25, 50, 75,100 meters from the Internet towers, with the results were 0.00149W/m², 0.017427W/m², 0.004144W/m², 0.002041W/m² and 0.000136W/m² respectively. The power density was measured at different hours of the day to find out the peak time, and the highest value of the power density was 0.0078112W/m² and 0.0076459 W/m² at the tenth and eleventh hours in the evening, respectively.

Keywords--Radiofrequency (RF) Radiation, Electromagnetic Radiation (EMR), Power density, Mobile tower, Standard for EMF exposure.

Introduction

The world is experiencing rapid technological progress, which has resulted in so many innovations that benefit the civilization. The Internet is regarded as one of the most significant and sophisticated achievements, as it has effectively reduced the whole world to the size of a small city. In this era, connecting to the Internet is no longer a luxury, but rather a necessity, since new Internet technologies have inspired a lot of interest in all sections of life, particularly in education (Ali et al., 2021). Its applications have developed to include commercial, educational, medical, cultural, and other sectors. In Iraq, the use of information technology by universities, colleges and schools is gradually increasing to transfer training and educational programs (Saeed et al., 2017), This sector depends on laws and standards issued by the Iraqi Ministry of Communications (IMC) and the Communications and Media Commission (CMC) (ALRikabi, 2016). Despite the existence of these laws and standards, there are some violations in Iraqi cities, especially Mosul city, which has become suffering from visual pollution and a lack of urban appearance due to the massive and rising number of Internet towers installed on the roofs of houses, buildings, and government institutions, as well as the inefficiency of their geographic distribution. The most commonly frequencies that use in wireless internet service inside Iraq can be classified into the 2.4 GHz frequency band and the 5GHz frequency band. the 2.4 GHz frequency band usually used in a Wi-Fi service transmitter (Router), which is used to deliver the service to various devices such as phones and computers inside the house, and is also used in the signal receiving device outside the house. In addition, a 5GHz frequency band, this band primarily used in the external Nanostation receiving device and to a lower extent in some routers, This band is characterized by its high data transfer speed and it has good stability, in addition to its high performance (EarthLink, 2020). When it comes to the harmful effects of radiation from internet networks and mobile phone towers, there are divergent opinions about whether or not continuous exposure to these radiations causes any health risks. Some studies have proven that the electromagnetic radiation (EMR) of telecommunication towers is not harmful as long as it radiates wave's less than internationally permissible limits (Hardell and Carlberg, 2020). While research evidence indicates that electromagnetic radiation exposure causes a variety of health issues such as previous studies of (Omojunikanbi et al., 2021; Meo et al., 2019; Miller et al., 2019). The human body also absorbs electromagnetic radiation, when it emits radiation Part of these electromagnetic waves is absorbed energy, which can cause health risks depending on the intensity of the emission and the duration of stay in interface with it (Bordin and Donchilo, 2018). The wireless transmission through the networks of the Internet towers is unknown and not used at the present time in the world, so most of the studies are related to the radiation emitted by the mobile phone station, but the nature of the electromagnetic waves and the way they are emitted are exactly the same as for the Internet towers. Similar studies have been conducted in many countries, such as the study of (Nahuku et al., 2020), where The RF radiation levels of mobile stations were measured and analyzed at different distances from the base station, and a maximum radiation level was 0.00139 W/m². Also, study of (Koppel et al., 2019) In Stockholm, Sweden.

Materials and Methods

Study Site

The research focused on the crowded neighborhoods with high population density, as well as the important areas in Mosul for both sides that filled with markets, such as (Al-Majmoa'a Al-Thaqafiyah Street, Al-Zohour neighborhood, Al-Muthanna neighborhood and Mosul Al-Jadidah area. In terms of size and population, the Tigris River divides Mosul into two main sides, the left and right sides, the left side defined by greater area and population compared to the right side. Thus, the number of Internet towers on the left side is greater than it is on the right side, reaching approximately 2257 towers, compared to the right side, in which the number of towers reaches 704 towers (Nineveh Communications and Informatics Department), where the density of towers decreases or increases according to the area and population density. 60 sites chosen on the left side and 30 sites on the right side of the city to measure the intensity of the radiation power emitted by the Internet network towers. As shown in Figure 1.

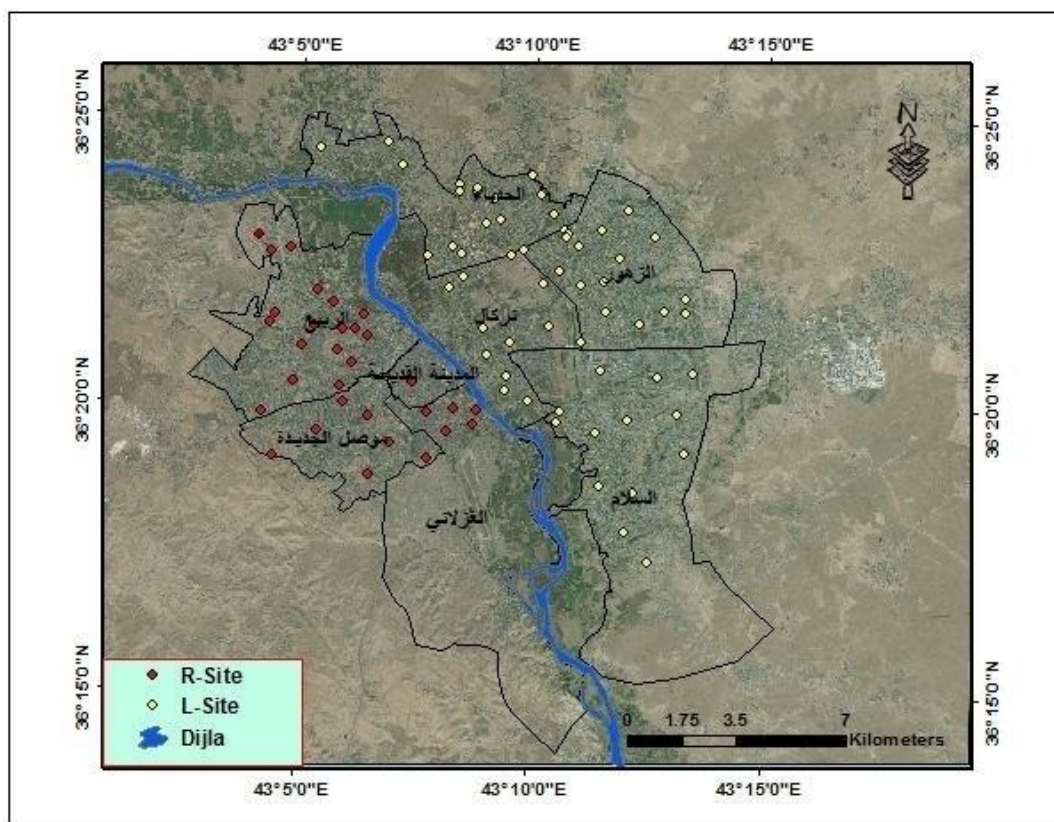


Figure 1. A map of Mosul city showing the distribution of measurement locations

Measuring device used in the project

In this study, the HF-B8G measurement gadget was used, which was manufactured by LATNEX Company in Canada, Toronto. This device is designed

for use in open space and in hard-to-reach measurement sites. It works on a simple principle of magnetic flux, which is very similar to the principle used in any electrical transformer this makes the measurement process easier. The device is used to measure and monitor the electromagnetic field intensity of Radio Frequency (RF). Because it is a broadband instrument, it can measure frequencies ranging from 10MHz to 8GHz. It can also be used for non-directional measurements because to the device's three-axis measurement sensor, which makes it very sensitive. The antenna is specific to the device and is attached to it because it is simple to install on the base unit and is designed for use in space. Different units of measurement can be used for the same parameter. This device gives readings of the instantaneous value, maximum value, average value and maximum average value of electromagnetic radiation (Latnex, 2022).



Figure 2. LATNEX®HF-B8G Professional High Frequency and RF Meter.

The Programs used:

1. ArcGIS 10.6.1
2. MAPS.ME
3. UTM Converter

Methods

The field measuring procedure lasted four months (January 2022-April 2022), and it required about 5 to 6 hours per day, five days a week, during peak hours from four o'clock in the afternoon to ten o'clock in the evening. The Information about the different sites that selected for measurement was collected, and the coordinates of the internet towers sites for the study areas were verified. The HF-B8G device was used at a 45° angle and a height of around 1.2-1.5m above ground level Pointing to the antenna as it was applied in previous studies (Parajuli et al., 2015; Abdulmohson, 2017; Ayinmode and Farai, 2013). All measurements

were made through using open space condition, which ensures that there are no obstacles or barriers that cause distortion or interference in the observed power levels. The electromagnetic power density was measured at its maximum and average values, with the data stabilizing after three minutes. As a result, recording each measurement took around 25-30 minutes at one tower. According to the Iraqi Ministry of Health and Environment's recommendations, the measuring process was repeated in the directions corresponding to the antennas. After capturing the measurements and storing them in the device's memory, they are analyzed and processed using the Excel application. As well as entering data using ArcGIS 10.6.1 to create IDW analysis maps, which display the distribution for levels of radiation power density for the study regions. During the field work, many internet network towers were found that contain a large number of internet transmitters. These towers are installed on the roofs of residential and governmental buildings and shops with different heights ranging from 15-30 meters as shown in Figure 3.





Figure 3. Internet broadcast towers.

Results and Discussion

Several points have been selected in various parts of Mosul city, especially in areas that contain high-density Internet towers. Where the maximum value of power density ranged between 0.00848W/m^2 - 0.001031W/m^2 and the average value of the power density is between 0.000141W/m^2 - 0.005362W/m^2 and the measurement results, as shown in Table 1, are significantly lower than international standards.

Table1

It shows the percentages of the highest recorded values of the max radioactive power density from the international determinants for the general population.

ICNIRP 10	Percentage of Determinants				Max Value W/m ²	Tower Symbol	Region
	CHINA 0.4	FCC 10	RUSSIA 0.1	IRAQ 4			
0.084%	2.12%	0.084%	8.48%	0.21%	0.00848	A5	Al-HADBA
0.074%	1.85%	0.074%	7.43%	0.18%	0.007431	A26	Al-Zohor
0.083%	2.08%	0.083%	8.35%	0.2%	0.008351	A17	Al-Andalus
0.062%	1.55%	0.062%	6.22%	0.15%	0.006227	C8	Msherfa
0.045%	1.14%	0.045%	4.56%	0.11%	0.007045	C18	Mosul Aljadedah

0.041%	1.05%	0.041%	4.19%	0.1%	0.005062	C12	Industrial Area
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Where the highest value of the radiation intensity was 0.00848W/m² for the tower (A5) in the Al-Hadbaa neighborhood on the city's left side, which is less than the Iraqi, Russian, Chinese, FCC, and ICNIRP standards by 99.79 %, 91.52 %, 99.92 %, 97.9%, and 99.92 % respectively. The highest value on the right side of the city was in the Mosul Al-Jadidah area, where it reached to 0.007045W/m² for the tower (C18), which is lower than the Iraqi, Russian, Chinese, FCC, and ICNIRP determinants, which have percentages of (99.89 %, 95.44 %, 99.95 %, 98.86 %, and 99.95 %) respectively. Perhaps the reason of this high power density because these areas are crowded with internet network towers. People who work near base stations especially on the top roof, such as maintenance workers, are exposed to a higher electromagnetic field than people who work far from these stations (Buckus et al., 2017; Marinescu and Poparlan, 2016). Therefore, the measurement results were compared with the international standards specified for people working near the base stations (Occupational), and the values were much lower than the permissible limits as shown in Table 2.

Table 2

shows the Percentages of the highest values of max radiation power density from the determinants for the occupational population.

Percentage of Determinants				Max Value W/m ²	Tower Symbol	Region
ICNIRP 50	CHINA 50	FCC 50	RUSSIA 10			
0.016%	0.016%	0.016%	0.084%	0.00848	A5	Al-HADBA
0.014%	0.014%	0.014%	0.074%	0.007431	A26	Al-Zohor
0.0167%	0.0167%	0.0167%	0.083%	0.008351	A17	Al-Andalus
0.012%	0.012%	0.012%	0.062%	0.006227	C8	Msherfa
0.014%	0.014%	0.014%	0.045%	0.007045	C18	Mosul Aljadedah
0.01%	0.01%	0.01%	0.041%	0.005062	C12	Industrial Area

When comparing the maximum value of the tower (A5) in the Al-Hadbaa neighborhood of 0.00848W/m², we see that it is 99.9% less than the Russian limiter and 99.98% less than the Chinese, FCC and ICNIRP determinants. We observe the power density for (A17) tower is less than the Russian limiter with 99.91% and less than the Chinese, FCC and ICNIRP determinants with 99.98%. The power density for (A26) tower in Al-Zohor neighborhood is less than the Russian limiter with 99.92% and less than the Chinese, FCC and ICNIRP determinants with 99.99%. The percentage of max value for (C18) tower in Mosul Aljadedah area is much lower than the Russian limiter with 99.95% and less than the Chinese, FCC and ICNIRP determinants with 99.98%.

These values are not significantly different from the values obtained in previous studies, such as the study of (Abdulmohson, 2017) that was completed in the Kut city of Iraq, which contain nearly 1250 towers using modern broadcast devices. Where the power density was between 411.2nw/cm² and 449.9nw/cm² and all

towers use a free license frequency (5 GHz) to broadcast the internet. But these values may differ from the values of the power density of mobile phone stations because of the frequency difference, as it is in many global studies, such as the study of (Buckus et al., 2017) that was conducted in Lithuania. This study showed the scientific field measurements of general exposure to (RF, EMR) specifically exposure to radio frequency radiation from mobile phone base station antennas and electromagnetic field strength (EMF) values in the environment. The electromagnetic RF power density values on the ground at distances of 50, 100, 200, 300, 400 and 500 meters from the base station were very low, ranging from 0.002 to 0.05 $\mu\text{w}/\text{cm}^2$. Figures (4, 5) show the distribution of the radiation power density emitted by internet towers for the measurement sites.

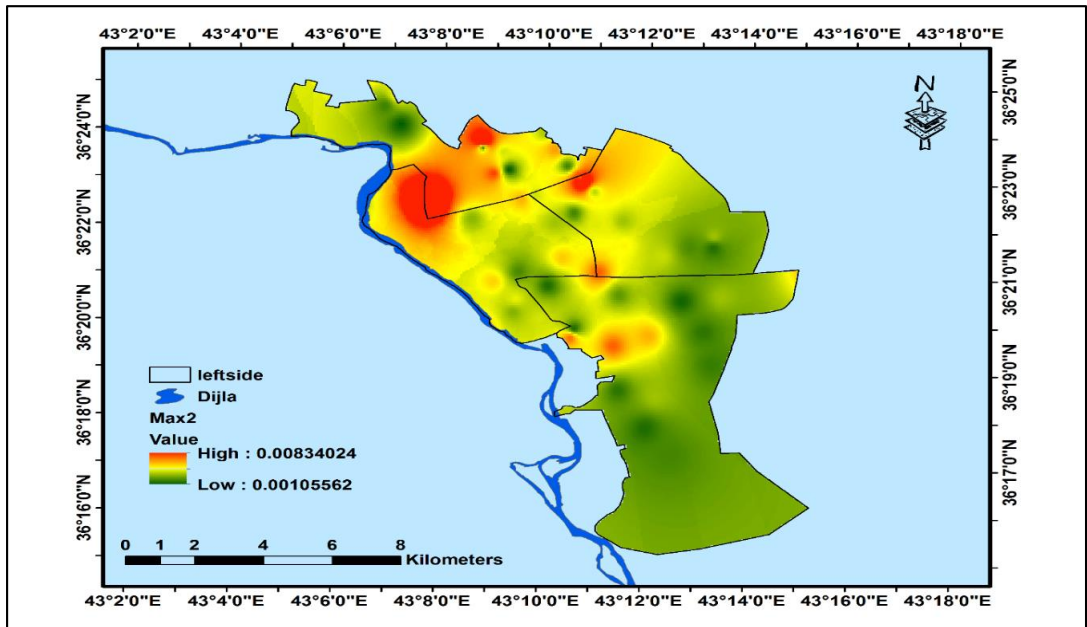


Figure 4. Shows the high intensity of radiation power in the Al-Hadbaa, Al-Andalus, and Al-Zohour neighborhoods on the city's left side

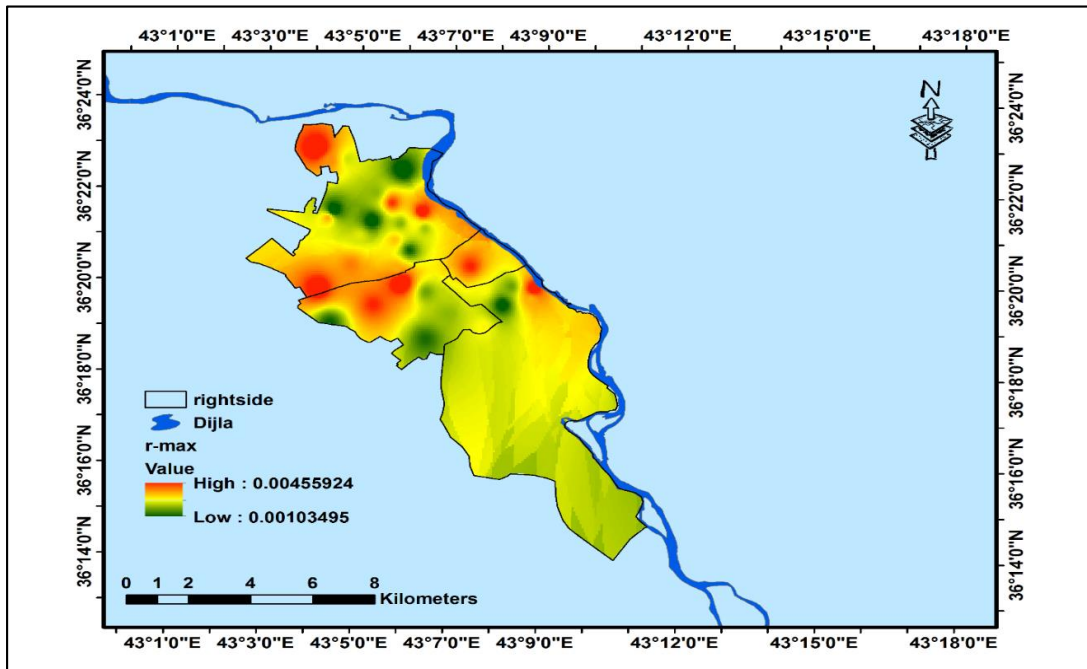


Figure 5. On the right side of the city, the high intensity of radiation power can be seen in the Mosul Al-jadedah, Mushairfah, and the Industrial area

Distance

For the effect of distance on the radiative power density values, random distances from the towers were selected, as followed in the studies (Abdulsalam et al., 2020; Abdulmohson and Ali, 2018; Ali et al., 2021; Nahuku et al., 2020; Buckus et al., 2017). The greatest value of the radiation intensity is at a distance of 25 meters from the tower, and this violates the inverse square law. Perhaps the reason for this is the inefficiency of the geographical distribution of the towers, as it is in many studies (Mohammed et al., 2021; Baltrėnas and Buckus, 2013; Parajuli et al., 2015). As shown in Table 3 and Figure 6.

Table 3
shows the difference in power density values with distance.

max power density W/M2	distance (m)
0.00149	10
0.010427	25
0.004153	50
0.002041	75
0.00076	100

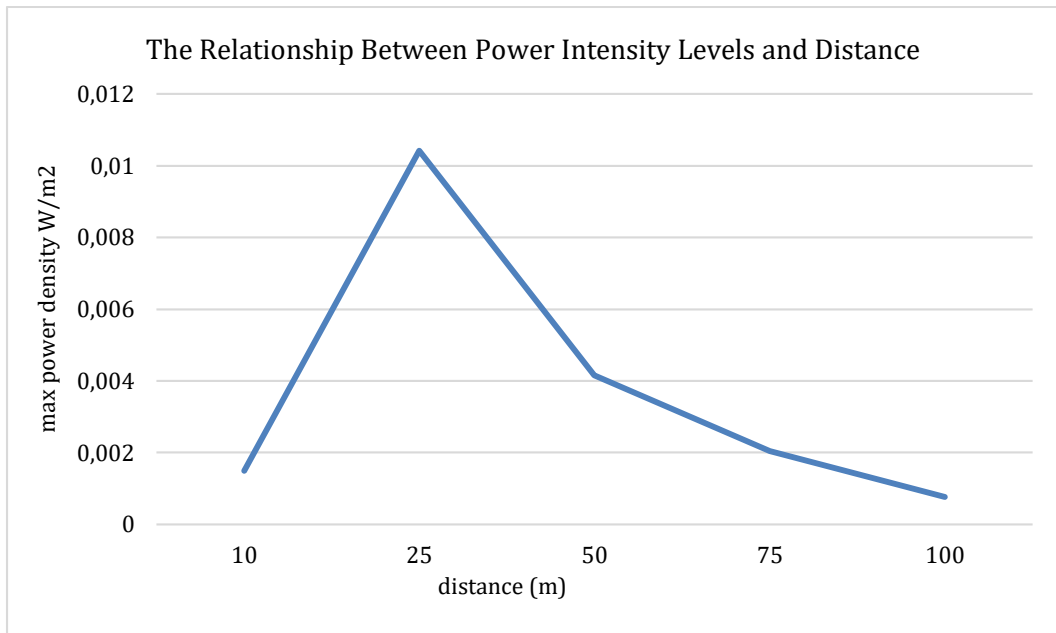


Figure 6: shows the different levels of radiation power, where the highest value reaches at a distance of 25 meters and then decreases

Peak time

From Table 4 and Figure 7 it is noted that the different levels of radiation power emitted from an Internet tower in the Al-Kindi neighborhood located on the left side of the Mosul city. A point 15 meter away from the tower was chosen and the readings were taken with the open space condition over a day at a rate of reading per hour starting from nine o'clock in the morning to one o'clock in the middle of the night. The differences in the levels of radioactivity appeared by increasing it after seven o'clock in the evening, reaching a peak at ten o'clock at night, and then starting to decline after twelve o'clock at night.

Table 4
Power density readings for different hours.

Max power density W/m ²	Time
0.0012	9:00AM
0.001361	10:00AM
0.00244	11:00AM
0.00253	12:00PM
0.002751	1:00PM
0.001474	2:00PM
0.001881	3:00PM
0.001672	4:00PM
0.001951	5:00PM
0.002518	6:00PM
0.003572	7:00PM

0.003829	8:00PM
0.0051684	9:00PM
0.0078112	10:00PM
0.0076459	11:00PM
0.0043977	12:00AM
0.0036855	1:00AM

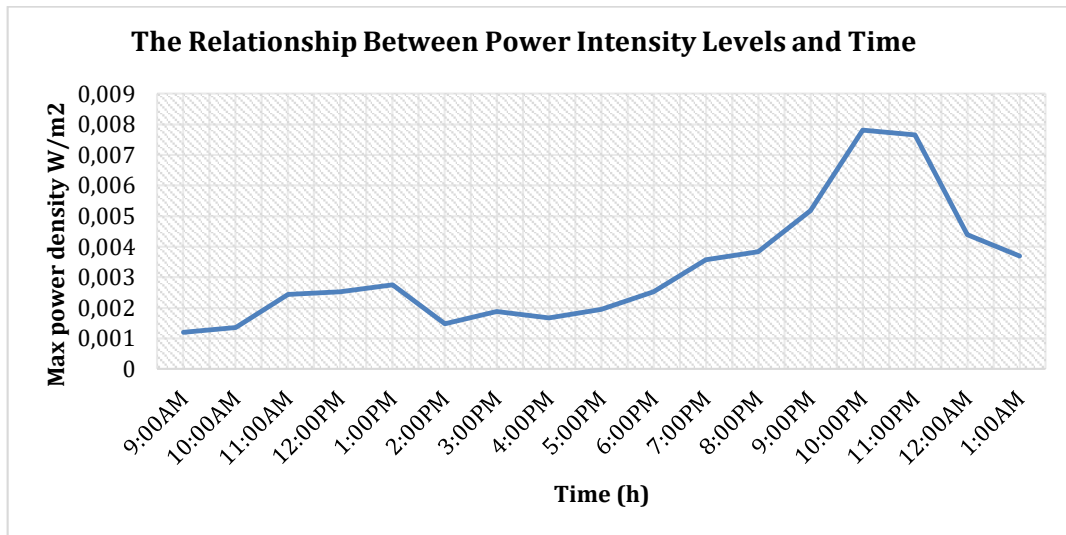


Figure 7. The differences in power intensity levels by increasing the power density after seven o'clock in the evening, reaching a peak at ten o'clock at night, and then starting to decrease after twelve o'clock at night

Conclusions

This paper aims to obtain measurements of the density of electromagnetic energy emitted from the networks of Internet towers for different places in the Mosul city, which contains approximately 2961 Internet towers on both the right and left sides of the city. Despite the towers' widespread distribution, the measured power density values are significantly lower than the international parameters, where the highest maximum energy density value was recorded, the left city side gets 0.00848W/m², while the right city side gets 0.007045W/m². The power density was measured at various distances from the towers with the maximum value reaching 20.017427W/m² at a distance of 25 m. The power density was measured at different hours of the day to find out the peak time, and the highest value of the power density was 0.0078112W/m² and 0.0076459 W/m² at the tenth and eleventh hours in the evening, respectively. Interference is a significant problem for Internet broadcasting using free frequencies. This interference forces Internet service providers (ISP) to find new devices with much power to send Internet signal to users, which means EMF exposure intensity may increase. This problem can be solved by completing the requirements of the national project for optical fiber as soon as possible. As this project will use optical cable to connect all switches in the Mosul city and then distribute Internet service to all homes using this technology, as well as imposing restrictions on Internet service providers in terms of the number of towers and adherence to the conditions for

erecting towers in terms of height and distance. Where the height of the antenna should not be less than 15 meters from the ground level, with the necessity of having a barrier or a non-metallic fence around the antennas, the antennas should not be installed in the yards of schools and hospitals, not even near them. The distribution of towers should be at regular distances so that each tower has a field of view to reduce the effect of obstacles that could lead to distortion or interference in the received signal.

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