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Electromagnetic Radiation Measurements from Mobile Base Stations in Sirte.

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ABSTRACT

The main objective of this work is to evaluate the power radiated from mobile base stations by measuring the power density of chosen base stations on particular schools and sites of local communication networks in Sirte city.

The measurements were conducted on three schools on which mobile phone base stations were installed and three open greenfield areas; the measurement was performed at different distances and directions from mobile base stations using RF Field Strength Meter instrument. The measured data were compared with International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, to ensure that the radiation levels are within the permitted levels.

Keywords: *EM radiation, base station radiations, EM hazard, ICNIRP, Power Density*.

1. Introduction

There is a substantial progression in wireless communication technology over the world which has led to install many communication antennas in numerous base station towers were placed on residences, schools, and hospitals as well as in many locations where people live and work. The hazards on public health from electromagnetic radiation from these mobile base stations and other electromagnetic radiation sources had been studied by government and non-government organisations over in many countries.[1]

the media has the most impact on rising these concerns, therefore, periodic measurements became necessary, especially, after the rapid growth of communication networks.

For Libya, measurements of electromagnetic radiation from mobile base station have been conducted to ensure that the electromagnetic radiation levels are within the permitted values which are defined by the international health organization.[2]

The power density is defined as the rate of the electromagnetic energy flowing per unit area which is used to measure the radiation level from antennas.

$$S = \frac{1}{2} Re[E \times H] = \frac{|E_{rms}|^2}{z_0} = |H_{rms}|^2 \qquad (1)$$

Where: E, H is electric and magnetic field intensity and Z= impedance of free space. [2]

The power density at any distance from an isotropic antenna can be determined as the ratio between the transmitted power and the surface area of a sphere at that distance. the power density inversely proportional to squared radius of that sphere, and it can be expressed as:[1]

$$S = \frac{p_{rad} G}{4\pi r^2} \qquad (2)$$

Where, S = Power density (W/m2), P = Power input to the antenna (W), G = Power gain of the antenna, r = Distance to the centre of radiation of the antenna (m).

2. International exposure guidelines

During the second part of the twentieth century, there was a concentration to establish and refining regulations and guidelines for radiation exposure to ionizing radiation. The International Radiation Protection Association (IRPA) organized a working group on non-ionizing radiation (NIR) in 1974, which looked into the issues that arose in the field of NIR protection. This working group was renamed the International Non-Ionizing Radiation Committee during the 1977 IRPA Congress in Paris (INIRC).[4]

Some countries have established their own standards for exposure limits by national authorities such as Switzerland and Italy. As an independent commission, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) was established. [4]. the primary distinctions are that they consider the exposure over time and use various criteria to define harm and negative health impacts. Other regulating bodies include the American National Regulations Institute (ANSI), which is part of the Institute of Electrical and Electronics Engineers (IEEE), for safety standards for EMF exposures, as well as the World Health Organization (WHO) and the Federal Communications Commission (FCC). ICNIRP and ANSI/IEEE standards are the most frequently recognized standards worldwide.[4]. These restrictions met the ICINRP's suggested frequency range for EMF exposure limits. Some guidelines are summarized in Table 1 .[2,4]

Table 1 Some international exposure guidelines.

guideline	Frequency range	Power density μw/ cm²
ICNIRP	400-2000 MHz	f/200
USA, Canada	300-1500 MHz	f/150
	1.5-100 GHz	10
United Kingdom	0.8-1.55 GHz	$41f^2$
	1.55-300 GHz	100
China	30 -3000 MHz	0.4
Japan	300-1500 MHz	f/150
	1.5-300 GHz	50*f
Russian	0.3-300GHz	$0.1(0.25^h)$

Where: h for rotating and scanning antenna.

** maximum allowed exposure in the presence of ionizing radiation and/or high temperatures (over 28°) should not exceed 1w.

3. Methodology of measurements

Measurements were carried at places where people live, work, or have frequent access. People are rarely exposed to the main beam because of the proximity to the base station tower under measurement, or due to shadowing by buildings. Measurements were taken from six distinct places in Sirte city, including base stations, inside buildings, roofs, and open areas.

Power meter "TriField Strength EMF Meter Model TF2" is selected for carrying out all the measurements. ". This meter detects the electric field of radio and microwaves (RF) ranging from 20MHz to 6GHz and represents the field strength as a power density ranging from 0.01 to 20 mwatts/m².

To ensure the validity of the measurements, the following parts of this procedure are used in this work using the , included the following:

- Measurements were taken at several places around the base stations.
- At each location, measurements were taken twice daily during peak and off-peak periods.
- The measurements were taken at each position three times in one day, at different times in each site.
- The measurements were repeated on multiple days to guarantee the accuracy of the results.

technical data were obtained from the operators (AL-Madar and Libyana companies) with the technical data of base stations at the six sites. The data set includes radiated powers, beam characteristics of sector antennas, and dish antenna radiated powers. Table 2 shows the antenna heights for all of the base stations.

Table 2the antennas for all the base stations.

Site	Height of First floor	Height of Second floor	Height of rooftop	Height of Antenna
Al-Fatah School	4.2 m	8.4m	12.6m	**16m**
Al-Sogor School	4.2m	8.4m	12.6m	16m
Al-Jeel Al-Jadeed School	-	-	4.2m	18m
7200 Neighborhood (Greenfield)	-	-	-	28m
Presidential residence (Qusur Aldiyafa-Greenfield)	-	-	-	24m
Al-Zaafaran (Greenfield)	-	-	-	26m

3.1 Site selection

- Measurements were taken in locations where people live, work, or often visit. The sites with the greatest number of antennas were chosen. Humans are rarely exposed to the primary beam, either because of their closeness to the mobile phone tower in issue or because of building protection. Six sites in Sirte were measured, and these measurements were obtained at a variety of various positions surrounding the base station. The following base stations have been chosen:

- Al-Fatah School.
- Al-Sogor School.
- Al-Jeel Al-Jadeed School.
- 700 Neighbourhood (Greenfield).
- Presidential residence (*Qusur Aldiyafa* -Greenfield).
- Al-Zaafaran (Greenfield).

3.2 *Instrumentation*

Power meter "TriField EMF Meter Model TF2 has been selected for power density measurements, It detects radio and microwave (RF) electric fields from 20 MHz to 6GHz and represents field intensity as power density ranging from 0.01 to 20 mW/m^2. it is shown in figure 1.

Figure 1 Power meter "TriField EMF Meter Model TF2

3.3 *Technical data of the Base Stations*

The base station antennas placed by the operators (AL-Madar company) over the specified sites are sector dipole antennas with a 120° coverage angle. The technical data of macro cellular base stations at the six sites has been submitted to us by the operators. The information include radiated powers, beam characteristics of sector antennas, and dish antenna radiated powers.

4. *Measurements*

Power density measurements were taken between 5-3-2020 and 24-3-2020, and then repeated between 1-12-2020 and 8-12-2020 to confirm accuracy.

The RF field strength meter used in our measurements can measure the power density of all mobile phone base stations and all radio and microwaves (RF) from 20 MHz to 6 GHz at the site. The data are presented as a function of the radial distances directly to the base station antennas irrespective of whether the path was obstructed by walls, roofs etc. The measurements were conducted using the RF field strength meter, in different locations in the same elevation and different elevation, and at different times.

4.1 Comparing measurements in different floors

Figure 2, Figure 3, and Figure 4 show the power radiation level under the antenna's tower on the rooftop and at different floors for the selected sites. It can be seen that the power density was maximum on the rooftop then decreased progressively in the lower floors.

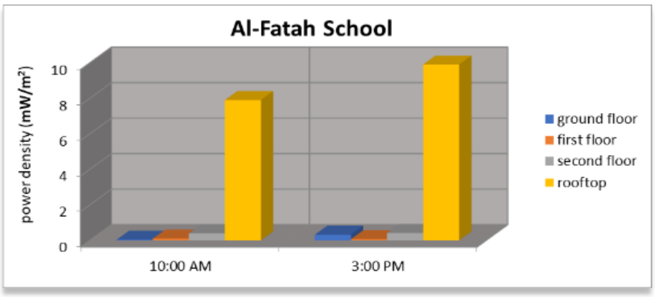

Figure 2 Power density level under the tower

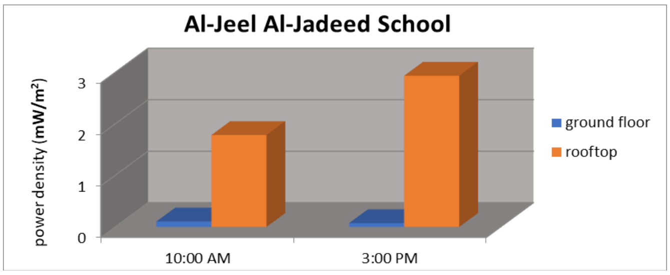

Figure 3 Power density level under the tower.

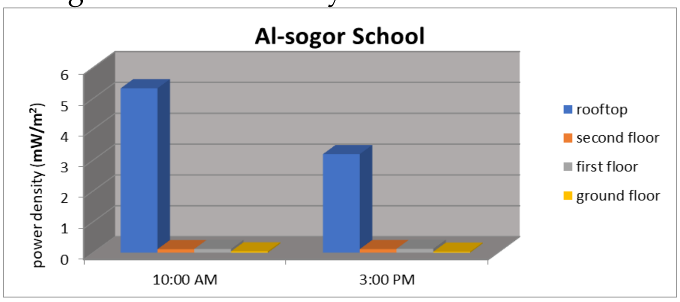

Figure 4 Power density level under the tower

4.2 Comparison of power density level between sites

The measurements were done for the previous six selected sites divided into three schools and three Greenfield and repeated along two days; Figure 5 shows the power density levels in the second floor for two schools at two different times. It is clear that the radiation power density in Al-Fatah School was the highest and if the power density in Al-Fatah School was used as reference then the power density in Al-Sogor School was 42.59% of that in Al-Fatah School.

Figure 6 shows the power density levels on the second floor for all schools at two days. It can be seen that the radiation power density on rooftop of Al-Jeel Al-Jadeed School was the highest; Al-Fatah School is second, and if the power density in Al-Jeel Al-Jadeed School was sit as reference then the power density in Al-Sogor School (the lowest) was 3.26% of that in Al-Jeel Al-Jadeed School.

Figure 7 shows the power density levels for all Greenfield sites at two days. it can be seen that the radiation power density in 700 Neighbourhood was the highest; Presidential residence (*Qusur Al Diyafa)* is second, and if the power density in 700 Neighbourhood was sit as reference then the power density in Al-Zaafaran (the lowest) was 6.84% of that in 700 Neighbourhood.

Figure 8 shows the power density levels for all Greenfield sites at two day, it can be seen that the radiation power density in Presidential residence (*Qusur Al Diyafa)* was the highest; Al-Zaafaran is second, and if the power density in Presidential residence (*Qusur Al Diyafa)* was sit as reference then the power density in 700 Neighborhood (the lowest) was 23.04% of that in Presidential residence (*Qusur Al Diyafa)*.

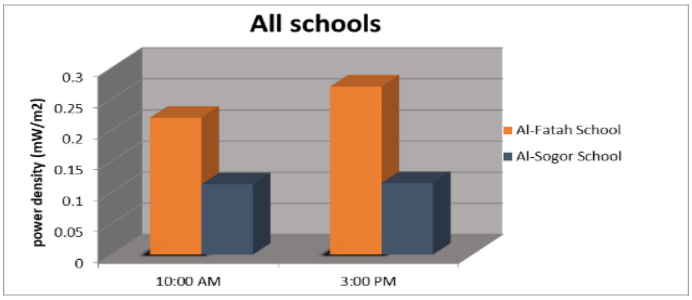

Figure 5 Power density level under the tower in Second floor

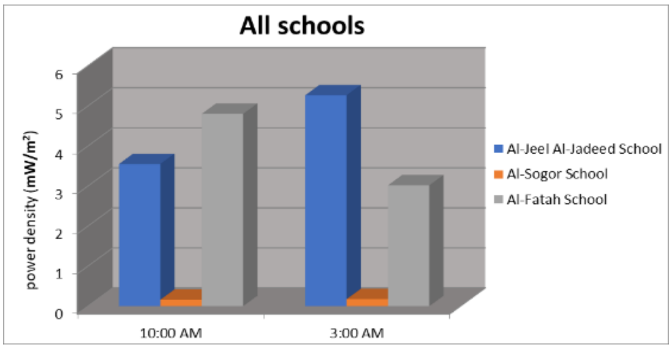

Figure 6 Power density radiation level in Second floor 15m-west the tower

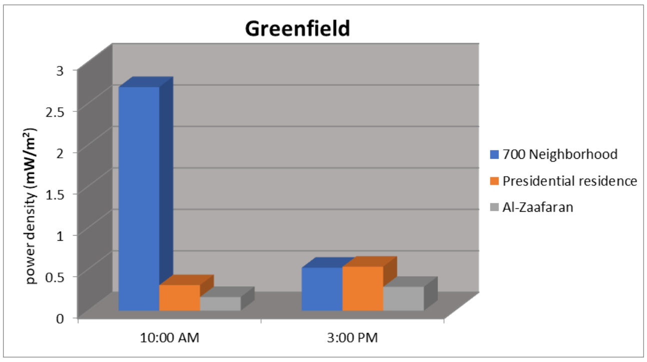

Figure 7 Power density level under the tower

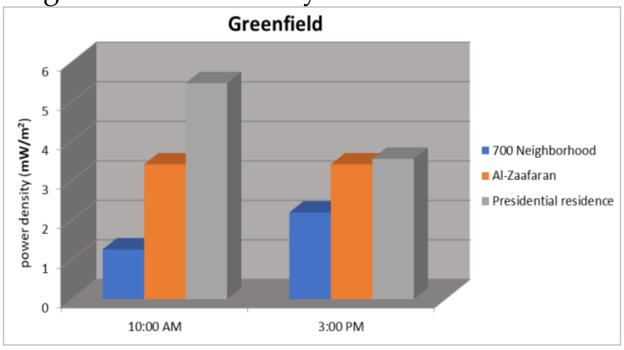

Figure 8 Power density level 15m south the tower

4.2 Measuring at different distances from antennas

The measurements were done at the south-east of the antennas at different distances and at different times. Figure 9 shows the power density variation at different distances and time in AL-Fatah school.

Figure 10 and Figure 11 show the power density variation at different distances and time in the south and north of the antenna's tower at 700 neighbourhoods, respectively.

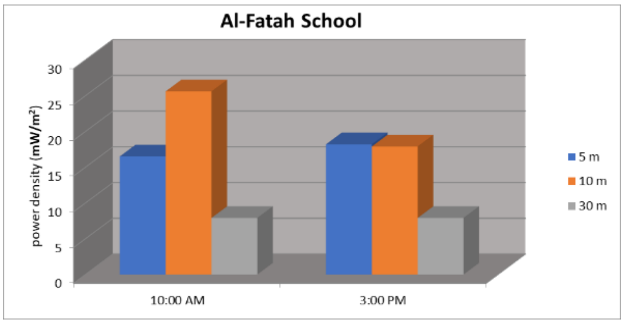

Figure 9 Power density level on -rooftop south-east the tower

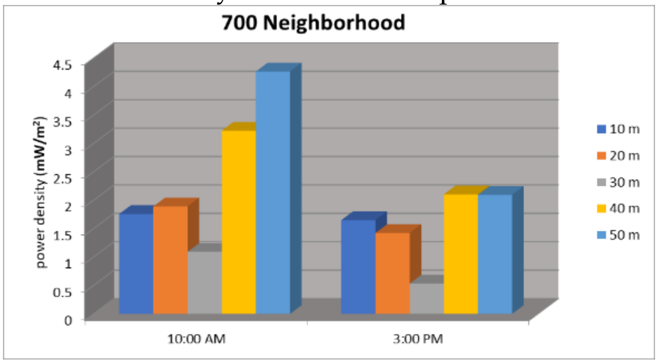

Figure 10 Power density level south the tower

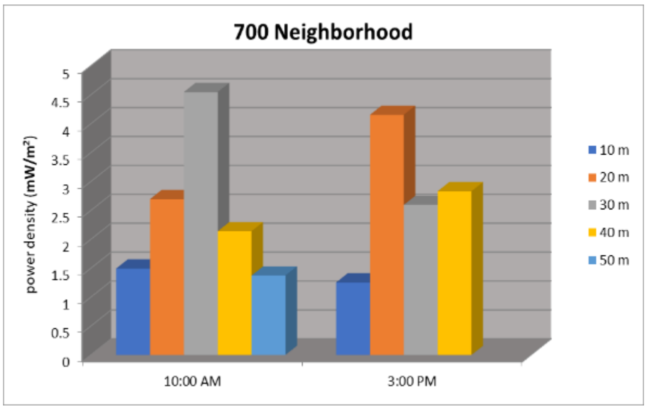

Figure 11 Power density level north the tower

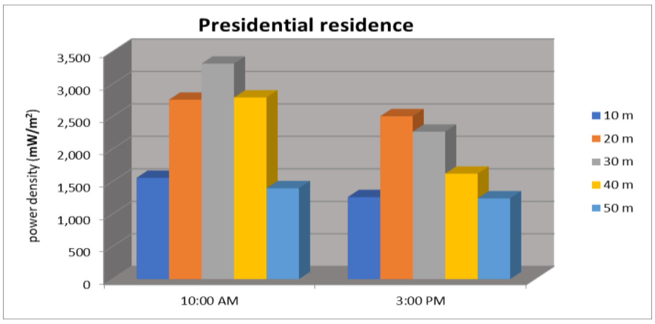

Figure 12 Power density level west the tower

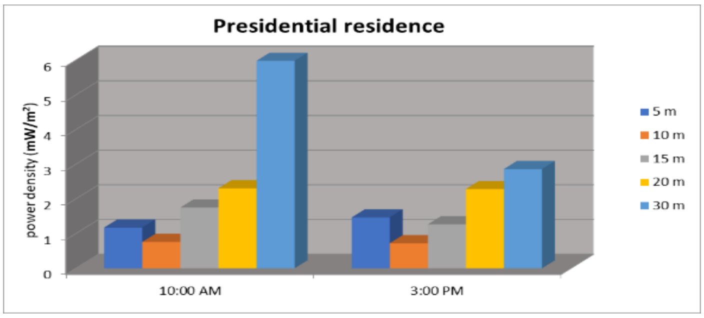

Figure 13 Power density level south-west the tower

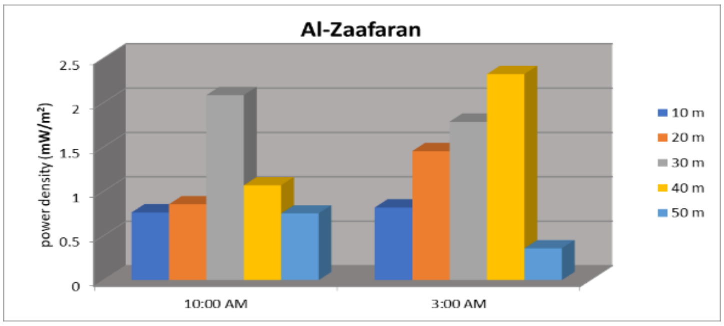

Figure 14 Power density level north the tower

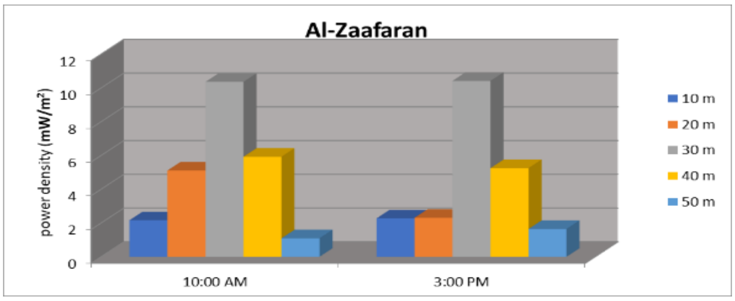

Figure 15 Power density level south-west the tower

Figure 12 and Figure 13 show the power density variation at different distances and time in the west and south-west of the antenna's tower at the Presidential residence (*Qusur Al Diyafa)* site, respectively.

Figure 14 and Figure 15 show the power density variation at different distances and time in the north and south-west of the antenna's tower at Al-Zaafaran site, respectively. For all sites, it can be shown that in most cases the power densities increased by increased distances till specific distances, then decreased by increased distances.

4.3 Measurements of the power density at different directions

The power density was measured at all antenna directions at the same distance in order to determine the radiation level at various antenna directions. The measurement was done for the following schools:

Figure 16 and Figure *17* show the power density variation in all directions at 5m at Al-Jeel Al-Jadeed and Al-Sogor schools' sites. The level of radiated power density was the highest in the north and west at Al-Jeel Al-Jadeed School, and in the west and east at Al-Sogor schools at different times 10:00am and 3:00pm, respectively.
Figure 18 and Figure 19 show the power density variation in all directions at 15m at Al-Presidential residence (*Qusur Al Diyafa)* and Al-Zaafaran sites. The level of radiated power density was the highest in the south at the Presidential residence (*Qusur Al Diyafa)* site, and in the west and east at Al-Zaafaran site at different times 10:00am and 3:00pm, respectively.

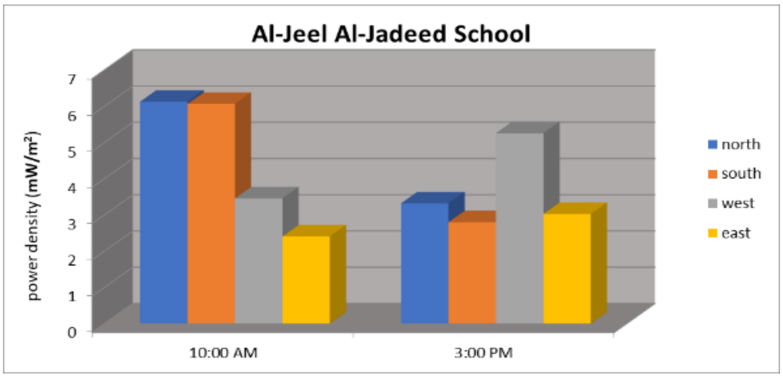

Figure 16 Power density level on rooftop-5m around the tower

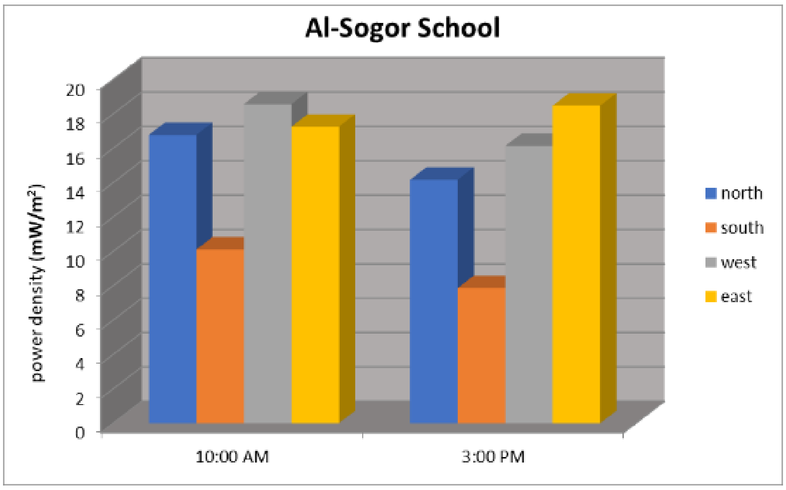

Figure 17 Power density level on rooftop-5m around the tower

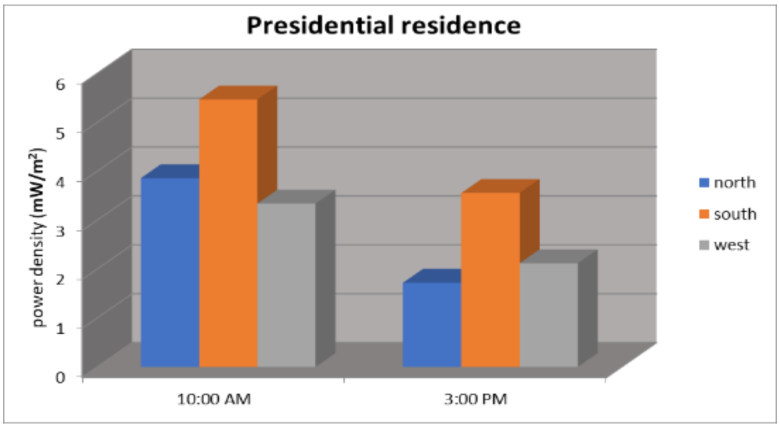

Figure 18 Power density level at 15m around the tower

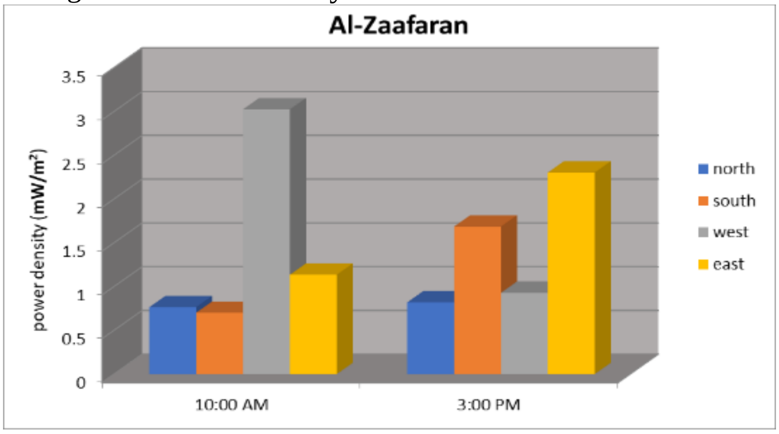

Figure 19 Power density level at 15m around the tower

5. Conclusions

In this paper, In this project, the density of the radiated power was measured from the antennas of mobile phone base station for six sites in the city of Sirte, divided into three schools and three Greenfield, during the period 5-3 2020 to 24-3-2020, and it was repeated in the period 1-12-2020 to 8-12-2020; to ensure the safety level of measured radiation in all sites, the ICNIRP standard was adopted as reference standard.

According to measurements made using one type of measurement equipment, Al-Sogor School's rooftop had the greatest amount of radiation, which was just 0.268% over the ICNIRP standard. The greatest RF level detected at any school was 0.036% of the ICNIRP norm, or 157.78 of maximum power density, according to measurements compared to measurements made in Canada in a study of five Vancouver schools [5].

The level of radiation of power density is higher at the midday time of the school hours than that at early morning or late in the day.

In general, all the measurements were much less than the ICNIRP standards, and some telecommunications companies had made studies before, but we did this study because we are an independent party with more reliability.

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