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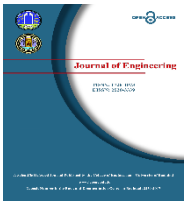

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Assessment of Electromagnetic Pollution in Some Hospitals and Schools in Al-Najaf City

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ABSTRACT

The tremendous benefits of using cellular phones, which began to increase and unprecedented spread worldwide last decade, were accompanied by harmful effects on the environment due to the increase in electromagnetic radiation (EMR) which be emitted from mobile phone towers. This effect on humans, animals, and plants, which is considered a form of environmental pollution, was sensed by developed countries and Environmental protection organizations. These countries have established restrictions and enacted laws to reduce their negative impact on living beings. The field survey included six major hospitals and 38 schools were distributed over the central neighborhoods in Al-Najaf city. The results showed that power density (PD) measurements for 4 out of 6 hospitals and 27 out of 38 schools were higher than the biological limit (BL) adopted in this article. This limit is considered as an indicator of the onset of a harmful effect on brain and body tissues. The highest value for PD in hospitals was 5.62 mW/m2 recorded in Al-Sadr Teaching Hospital. PD measurements ranged from1.33 from 3.92 mW/m2 in the selected schools where its readings exceeded the BL. When comparing the PD measurements at the selected sites with limits set by the "International Commission on Non-Ionizing Radiation Protection (ICNIRP)" they were less than the recommended limit in those specifications. All values of specific absorption rates (SAR) in W/Kg were below the ICNIRP Guidelines' limit. However, they were above the biological limit for four hospitals and several of the selected schools.

Keywords: Power density, Electromagnetic pollution, Specific absorption rate, Electromagnetic radiation**.**

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تقييم التلوث الكهرومغناطيسي في بعض مستشفيات ومدارس مدينة النجف

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الخلاصة

الفوائد الهائلة لإستخدام الهاتف الخلوي والتي بدأت بالأزدياد والأنتشارغير المسبوق في جميع أنحاء العالم في العقد الأخير، كانت مصحوبة بانتشار أثار ضارة على البيئة نتيجة لأزدياد أنتشار الأشعاع الكهرومغناطيسي المنبعث من أبراج الهاتف الخلوي. هذا التاثير الضار على الأنسان والحيوان والنبات يعتبر شكل من أشكال التلوث البيئي .

هذا التلوث الجديد تحسست به الدول المتقدمة والمنظمات الدولية لحماية البيئة . هذه الدول بدأت بوضع محددات وسنت تشريعات لتقليل أثاره الضارة على الكائنات الحية . الهدف الرئيسي للدراسة الحالية هو تقييم التلوث الكهرومغناطيسي الناتج من أبراج الهاتف الخلوي على الكائنات الحية خصوصاً الأطفال والمرضى في مدينة النجف . المسح الميداني للدراسة شمل ست مستشفيات رئيسية وثمانية وثلاثين مدرسة موزعة على الأحياء الرئيسية في مدينة النجف . نتائج الورقة البحثية الحالية بينت أن قياسات كثافة القدرة لأربع مستشفيات من أصل ستة ولسبعة وعشرين مدرسة من أصل ثمانية وثلاثين مدرسة مشمولة بالمسح الميداني كانت أعلى من الحد البايلوجي المعتمد في هذه الدراسة ،هذا الحد يعتبر بداية التأثير الضار على أنسجة الدماغ وانسجة الجسم الأخرى للأنسان. أعلى قيمة لكثافة القدرة كانت 5.62 ملي واط لكل مترمربع مسجلة في مستشفى الصدر. مديات قياس كثافة الطاقة تراوحت من 1.33 الى 3.92 ملي واط لكل مترمربع في المدارس التي تجاوزت الحد البايلوجي. لكن عندما نقارن قياسات كثافة الطاقة بمحددات عالمية أخرى مثل المحددات التي وضعتها اللجنة الدولية للحماية من الأشعاع غير المؤين (ICNIRP) نجدها أقل بكثير من تلك المحددات. ان كل قيم معدل الأمتصاص النوعي (SAR) كانت ايضا أقل من المحددات الموضوعة من قبل (ICNIRP) لكن تلك القيم كانت أعلى من الحد البايلوجي الخاص ب(SAR) لأربع مستشفيات ولعدد من المدارس المختارة في هذه الدراسة.

الكلمات الرئيسية: كثافة الطاقة ، التلوث الكهرومغناطيسي، معدل الأمتصاص النوعي، الأشعاع الكهرومغناطيسي.

1. INTRODUCTION

(Shashank Vijay and Mahendra Pratap Choudhary 2017) defined electromagnetic field (EMF) radiation, as photons' flow in space where the photons contain energy. Depending on the amount of energy in it, different types of radiation may be defined. EMF radiations are categorized into two types, known as ionizing radiation and non-ionizing radiation (NIR). Ionizing radiations contain the energy sufficient to overcome the binding energy of electrons in atoms or molecules, hence creating ions. Examples of ionizing radiation are UV rays and X-rays. They add that "NIR are those which do not carry much energy per quantum to ionize atoms or molecules. Examples are low-frequency radiations such as radio waves and microwaves". Nowadays, cities confront the most powerful EMF" in terms of NIR due to the presence of transmitters for mobile communication in crowded areas. This type of source constantly grew in the last years because of the large number of mobile services providers and antenna sites **(James, 2009; Ioan and Claudiu, 2016**). After long-term NIR exposure, common health risks might comprise "hypersensitivity syndromes, cognitive declines, autonomic dysfunctions, and brain tumors" **(Croft et al., 2002; Levitt and Lai, 2010)**. Numerous studies also stated that high EMF exposure was connected with a greater danger of childhood leukemia **(Kabuto et al., 2006)**. **(Hardell et al., 2005)** asserted an apparent connection between cordless and mobile phone use with conditions such as "lymphoma, malignant and benign brain tumors", **(Hardell, Carlberg, Hansson, 2006)** as well as other problems including changes in blood pressure **(Braune et al., 1998; Genuis, 2007)**. Young humans are probably more vulnerable to environmentally

poisonous materials. They may receive higher portions than adults either because of "developing skulls of children or because of their smaller body size". They might be exposed to higher electromagnetic absorption from the exposure to EMF's than adults **(Saunders and Jefferys, 2007; Behari et al., 2012)**. These EM waves are even more hazardous when there is a 20-meter distance. Not only this, but these may also bring about biological defects and" more severe mutations in DNA" **(Aggarwal and Gupta, 2011)**. Low-frequency radiations could also cause hormonal problems. The hormone 'melatonin' production is interrupted and causes "Alzheimer's disease, Parkinson's disease, and many cardiac, neurological and ophthalmological diseases" **(Goswami, 2010)**. At the same time, lower animals are stated to very sensitive to EMF. It is noted that animals like mice make their living brooding holes not close to the high electric field, and bees block-up their hives in the continuous presence of NIR and EMF **(Repacholi, 2003)**. According to **(Balmori, 2009**), EMR can exert a repulsive behavioral response in bats and birds such as sparrows. **(Balmori 2009)** concluded that EMR is a form of EMP which might damage wildlife. It was noticed that in the nearby high voltage installations, changes might happen in some plant species. Thus, some species remain inferior in size. In contrast, other species grow excessively or develop alternations in reproduction, like producing a large number of seeds, even flourishing, or not seeding at all, or producing seeds of lousy quality **(Doru Vatau et al., 2015)**. Previous studies mentioned above have shown that the harmful effects of EMR pollution include humans, animals, plants, and the entire ecosystem. It is also clear that many international organizations concerned with environmental affairs and developed countries consider EMR as a type of environmental pollution (EP). Therefore, it established specifications and enacted laws to limit its harmful effects. This article aims at assessing the levels of EMP emitting from mobile phone towers near the sites of some hospitals and schools of Al-Najaf city in Iraq. This research paper also aims to know the effect of EMP on the health of children and patients, also, to compare the levels of EMP in those locations with the allowable limits. Najaf is a city with a population of 1,500,522 people (according to 2017 statistics). Its geographical area is 28,824 square kilometers, and it lies within a longitude of 44º19' E and the latitude of 31º59’ N and is 70 meters above the mean sea level **(Abdulkareem, 2018).**

2. MATERIALS and METHODS

The current paper was carried out for three months, from 1st May to1st August 2020. Two parameters were used in this study, namely the PD and SAR to determine and know the levels of exposure to EMR at the selected sites. PD measurements were performed by Tenmars, TM-196, which is one of the devices that detect NIR in frequency ranges from 10 MHz to 8 GHz. This device is a 3-Axis (isotropic) Radiofrequency, a field strength meter with three-channel measurement sensor produced by Tenmars Electronics Co.Ltd., Taiwan. This device is used to measure the high-frequency electromagnetic strength in terms of Electric Field, Magnetic Field, and PD with their instantaneous, average, and maximum value (User's Manual). The readings were allowed to stabilize for 60 to 120 seconds before noting them in the maximum average mode. For each chosen site, five measurements were performed for different spots around the site, after which the average of readings was taken. The meter is positioned vertically at the height of 150 cm above the ground level. This height represents the average height of a person. The readings in the device for measuring the PD were in milliwatts per square meter.

Measurements of the fieldwork included six main hospitals in addition to 38 schools distributed in different neighborhoods of Al-Najaf city, as shown in **Fig. 1**. The "rate at which radiation is absorbed by the human body is measured in terms of SAR. It is described as the transfer of energy from electric and magnetic fields to charged particles in an absorber". In this work, "local SAR has been estimated at a point on the brain as the absorber. Local SAR is related to the electric field through the equation" **(Obahiagbon and Isabona, 2015; Dhami, 2012; Griffiths, 2010; Kumar, Ahmad & Sharma, 2010; Vorst, Rosen, & Kotsuka. 2006; Gandhi, 1990; Guy and Chow, 1986)**:

$$S = E \times \mathrm{H} = \frac{E^2}{377} \quad (1)$$

$$SAR = \frac{\sigma|E^2|}{\rho_b} \quad (2)$$

Where

$\sigma|E^2|$ = Absorbed PD by human brain tissue

E = Electric field strength (V/m).

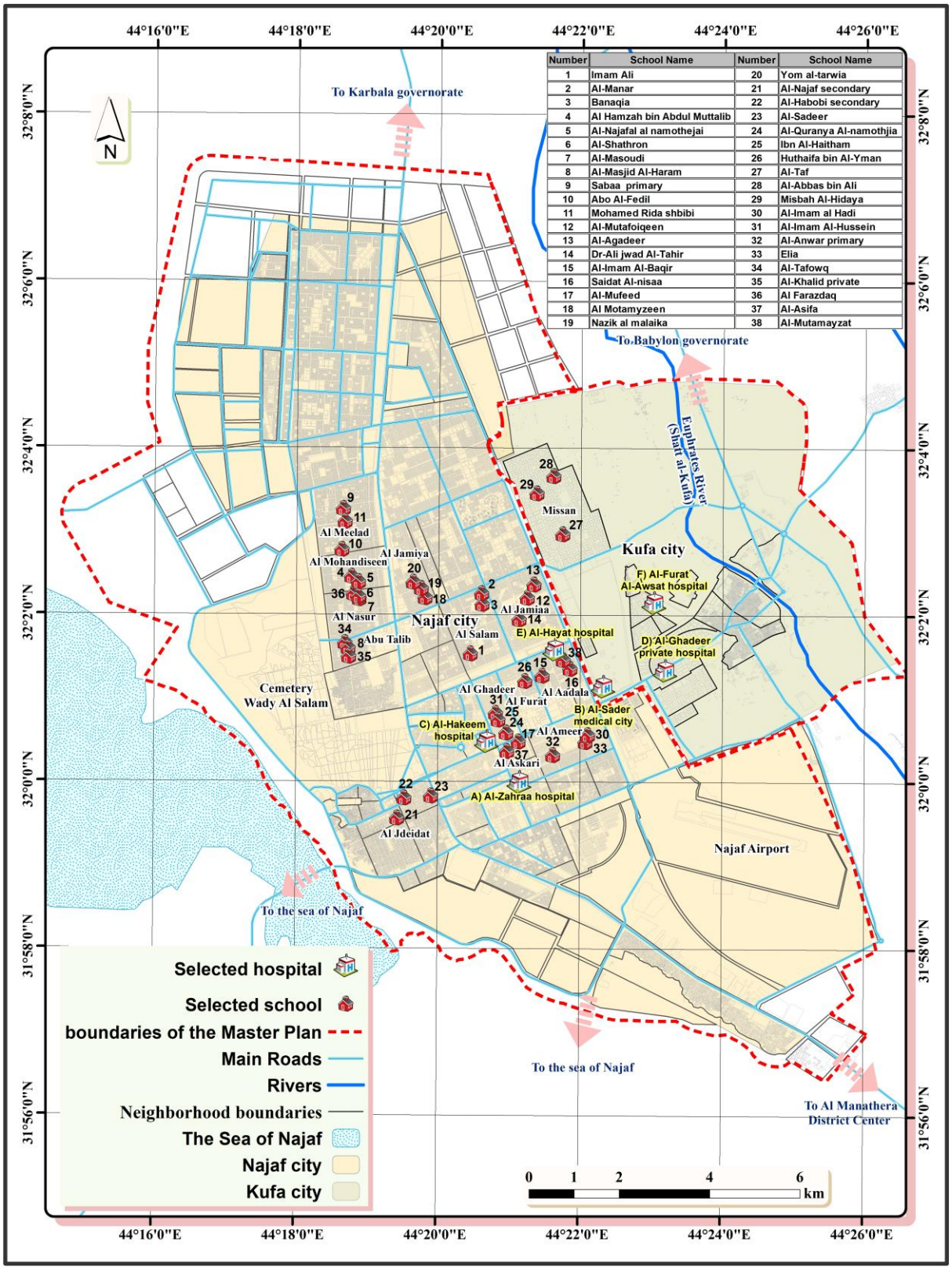
H = Magnetic field strength (A/m).

S = PD (mW/m^2).

σ = conductivity of the human brain tissue ($\frac{1}{ohm \times m}$).

ρ_b = Mass density of human brain tissue (kg/m^3).

The PD values measured by the Tenmars in mW/m^2 units were used to compute SAR Using Eq.(2). **Table1**. shows the values of σ and ρ_b constants according to the frequencies shown in it.



Number	School Name	Number	School Name
1	Imam Ali	20	Yom al-tarwia
2	Al-Manar	21	Al-Najaf secondary
3	Banaqia	22	Al-Habobi secondary
4	Al Hamzah bin Abdul Muttalib	23	Al-Sadeer
5	Al-Najafal al namothejai	24	Al-Quranya Al-namothjia
6	Al-Shathron	25	Ibn Al-Haitham
7	Al-Masoudi	26	Huthaifa bin Al-Yman
8	Al-Masjid Al-Haram	27	Al-Taf
9	Sabaa primary	28	Al-Abbas bin Ali
10	Abo Al-Fedil	29	Misbah Al-Hidaya
11	Mohamed Rida shbibi	30	Al-Imam al Hadi
12	Al-Mutafoiqeen	31	Al-Imam Al-Hussein
13	Al-Agadeer	32	Al-Anwar primary
14	Dr-Ali jwad Al-Tahir	33	Elia
15	Al-Imam Al-Baqir	34	Al-Tafowq
16	Saidat Al-nisaa	35	Al-Khalid private
17	Al-Mufeed	36	Al Farazdaq
18	Al Motamyzeen	37	Al-Asifa
19	Nazik al malaika	38	Al-Mutamayzat

Figure 1. Selected sites in the field survey included (38) schools and (6) hospitals distributed in Al-Najaf city's main neighborhoods.

Table 1. Conductivity and mass density for the human brain tissue **(Dhami, 2012).**

Frequency (GHz)	Conductivity ($\frac{1}{ohm \times m}$)	Mass density (kg/m^3)
0.9	0.7665	1030
1.8	1.1531	1030
2.1	1.310	1030

3. LIMITATIONS OF ELECTROMAGNETIC RADIATION POLLUTION

To compare the PD measurements in this research paper, the ICNIRP Guidelines were adopted for being widespread and approved by most countries of the world, especially developed countries. For example, Indian standards considering India as one of the Asian countries adopted the ICNIRP guidelines before 1/9/2013. After the mentioned date, its specifications were updated to be 10% of the previous specifications. Likewise, the PD measurements were compared to Austria, Salzburg City determinants. They adopted the lowest permissible level of EMR pollution, which gives a clear indication of minimizing the harmful effect of EMP. Adopting the mentioned international specifications was due to the absence of the Iraqi specifications related to the permissible limits of NIR emitted from mobile phone towers. There are many other international specifications as well as the specifications adopted in this paper, as shown in **Table 2**.

Table 2. The maximum permissible exposure limit of PD **(NTA, 2013)**.

S.N.	Specification	PD (mW/m^2) for GSM-2100	PD (mW/m^2) for GSM-1800	PD (mW/m^2) for GSM-900
1	ICNIRP	10500	9200	4500
2	India(from 1/9/2013)	1050	920	450
3	Poland, China, Italy	100	100	50
4	Austria, Salzburg City	1	1	0. 5

Where GSM is Global system for mobile communication

To compare the values of SAR, two specifications were used, the first ICNIRP being the most reliable specifications in most countries of the world. The second was BL, where the values above it are considered the beginning of harmful changes in cells and tissues, especially brain tissue **(de Pomerai et al., 2000)**. **Table (3)** shows the maximum permissible level for SAR, which was adopted in the current research.

Table 3. The maximum allowable limit of SAR **(de Pomerai et al., 2000; Dhami, 2012)**.

S.N.	specification	(W/Kg) for GSM-2100	(W/Kg) for GSM-1800	(W/Kg) for GSM-900
1	ICNIRP	2	2	2
2	Biological limit	0.001	0.001	0.001

4. RESULTS AND DISCUSSION

The present study's field survey included six governmental and private hospitals and 38 schools distributed over 16 central neighborhoods in AL-Najaf city. PD measurements for 27 out of 38 schools exceeded the biological limit (1 mW/m^2), as shown in **Fig. 2.** The exceeded values ranged from 1.33 to 3.92 mW/m^2. It was noticed from the mentioned figure that the highest value of PD was at site 26, which represents Huthaifa bin Al-Yman school in the Al-Furat neighborhood. This is due to the presence of five communication towers; the closest to the school was 100 meters away, and internet towers close to the school mentioned above. It has been observed in other the schools when the PD exceeds the permitted BL, the communication towers were 40 to 350 meter away from these schools. The number of communication towers surrounding some of these schools exceeded three towers in different directions and contained a large number of antennas. The data in **Fig. 3** show hospitals that have been exposed to levels of radiation higher than the BL adopted in this study. The highest PD rate was (5.62 mW/m^2) in Al-Sadr Hospital, which is the most significant hospital in Al-Najaf city. This study's PD measurements are less than the permissible values in the specifications of some other countries shown in **Table 2**. This gives an impression of the disparity of those countries in the limits they consider harmful to public health. Comparing the results in this study with the BL approved by Salzburg City in Austria is considered a safety factor to ensure that the brain tissue is not affected by the EMP emitted by cell phone towers. Hence, the real harmful effects on body tissues begin after this limit is exceeded.

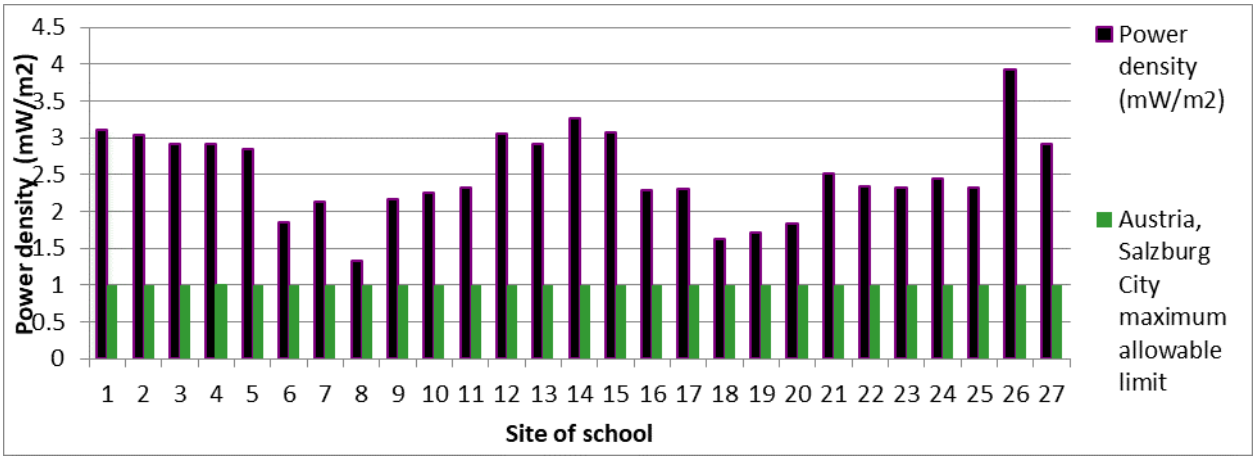


Figure 2. The level of EMR exceeding the BL for 27 out of 36 schools.

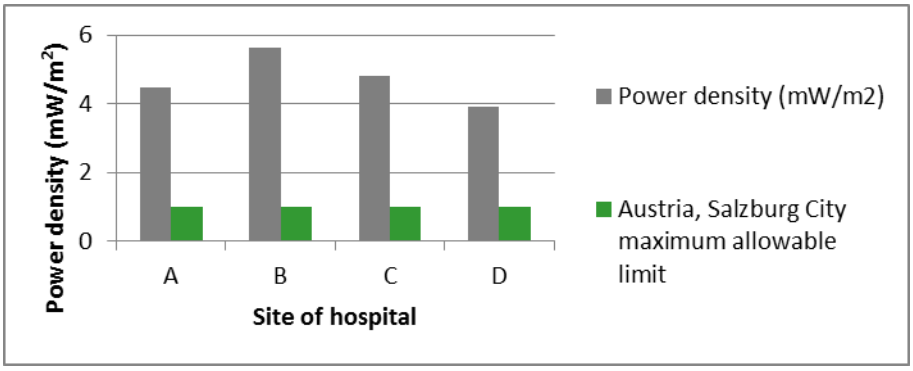


Figure 3. The level of EMR, which is beyond the BL for 4 out of 6 hospitals.

It was noticed that the results in **Table 4**. showed that the SAR values for hospitals were much less than (2W/Kg), whereas when comparing the mentioned data for all frequencies, all of them are above the biological limit. The highest calculated value for SAR for all frequencies was at location B, which represents Al-Sadr Hospital. The highest percentage exceeding the biological limit was 160%, 240%, and 270% for the frequencies 0.90 GHz, 1.80 GHz, and 2.10 GHz, respectively.

Table 4. SAR values for 4 out of 6 hospitals for 0.90 GHz, 1.80 GHz, and 2.10 GHz.

Site of hospital	SAR for 0.90 GHz (W/kg)	SAR for 1.80 GHz (W/kg)	SAR for 2.10 GHz (W/kg)	Biological limit (W/kg)	Allowable public limit of ICNIRP (W/kg)
A	0.0013	0.0019	0.0021	0.001	2
B	0.0016	0.0024	0.0027	0.001	2
C	0.0014	0.0020	0.0023	0.001	2
D	0.0011	0.0017	0.0019	0.001	2

Data of **Table 5** shows that several schools' SAR values exceeded the biological limit. The highest percentages of exceeding the biological limit were 110%, 170%, and 190% for 0.90GHz, 1.80GHz, and 2.10 GHz, respectively, at site 26, which represented Huthaifa bin Al-Yman school in the Al-Furat neighborhood. Data from the table above also showed that all SAR values for chosen schools were much less than the recommended limit in ICNIRP specifications.

Table 5. SAR values for 27 out of 36 schools for 0.90 GHz, 1.80 GHz, and 2.10 GHz.

Site of school	SAR for 0.90 GHz (W/Kg)	SAR for 1.80 GHz (W/Kg)	SAR for 2.10 GHz (W/Kg)	Biological limit (W/Kg)	Allowable public limit of ICNIRP (W/Kg)
1	0.0009	0.0013	0.0015	0.001	2
2	0.0009	0.0013	0.0015	0.001	2
3	0.0008	0.0012	0.0014	0.001	2
4	0.0008	0.0012	0.0014	0.001	2
5	0.0008	0.0012	0.0014	0.001	2
6	0.0005	0.0008	0.0009	0.001	2
7	0.0006	0.0009	0.0010	0.001	2

8	0.0004	0.0006	0.0006	0.001	2
9	0.0006	0.0009	0.0010	0.001	2
10	0.0006	0.0009	0.0011	0.001	2
11	0.0007	0.0010	0.0011	0.001	2
12	0.0009	0.0013	0.0015	0.001	2
13	0.0008	0.0012	0.0014	0.001	2
14	0.0009	0.0014	0.0016	0.001	2
15	0.0009	0.0013	0.0015	0.001	2
16	0.0006	0.0010	0.0011	0.001	2
17	0.0006	0.0010	0.0011	0.001	2
18	0.0005	0.0007	0.0008	0.001	2
19	0.0005	0.0007	0.0008	0.001	2
20	0.0005	0.0008	0.0009	0.001	2
21	0.0007	0.0011	0.0012	0.001	2
22	0.0007	0.0010	0.0011	0.001	2
23	0.0007	0.0010	0.0011	0.001	2
24	0.0007	0.0010	0.0012	0.001	2
25	0.0007	0.0010	0.0011	0.001	2
26	0.0011	0.0017	0.0019	0.001	2
27	0.0008	0.0012	0.0014	0.001	2

5. CONCLUSIONS

During the work of the current study, the following conclusions were reached:

1. Levels of radiation exposure which represented by PD in 27 out of 38 schools and 4 out of 6 hospitals, were above the BL adopted in this study, where the limit begins with the real harmful effects on brain and body tissues.

2. The highest reading of the PD of the selected schools was 3.92 mW/m^2. It was recorded in Huthaifa bin Al-Yman school in Al- Furat district. It is due to a large number of communication towers and their proximity to the school.
3. The maximum PD was (5.62 mW/m2) near Al-Sadr medical city. This hospital is crowded with patients, companions, a large number of health care employees, and workers. It is linked to the increase in radiation pollution resulting from increased cell phone use, besides affecting many mobile phone towers near its location. Although this reading is more than BL, it remains much less than the ICNIRP Guidelines and other international specifications.
4. The SAR for all sites measured in this study did not exceed the permissible and recommended limit in the ICNIRP specification.
5. The highest percentage of the SAR value exceeded the biological limit was recorded in Huthaifa bin Al-Yman School, where it reached 110%, 170%, and 190% for 0.9GHz, 1.8GHz 2.1 GHz, respectively.
6. When SAR values were compared with the biological limit, 4 out of 6 hospitals were found to be higher than it at all frequencies. Al-Sadr Hospital recorded the highest percentage of overtaking where it reached 160%, 240%, and 270% for the frequencies 0.9 GHz, 1.8 GHz, and 2.1 GHz, respectively.
7. There are no Iraqi specifications, limitations, and laws that protect human beings and the environment from the harmful effects of EMP.
8. There is a random distribution of communication towers near many school and hospital sites, in addition to a large number of private schools near the towers. Those sites are chosen without prior scientific planning that takes into consideration preserving the health of children.

6. RECOMMENDATIONS

1. Establishing Iraqi specifications and determinants and enacting appropriate legislation, similar to developed countries, to limit the effects of EMR emitted from cell phone towers. This work will reduce the harmful effects of these rays on all living beings and the environment.

2. Cell phone towers should not be installed at a distance of fewer than 500 meters from hospitals or schools to reduce health risks to children and patients.

3. The highest levels of EMR pollution were near sites surrounded by more than one cell phone tower. Therefore, we recommend that no more than one tower should be placed near schools and hospitals.

4. Urge researchers and environmental protection organizations to conduct studies that show the effects of exposure to EMP for long-term periods in order to find out the

interrelationship between some diseases such as leukemia prevalent among children and exposure to NIR over long periods.

5. It is recommended that the environmental protection authorities in Najaf governorate obligate the telecommunications companies responsible for installing mobile phone towers to finance the environmental impact assessment studies, which are preferably conducted periodically. In addition to assigning environmental scientists in educational institutions to conduct independent studies about the environmental impact assessment to detect the harmful effect on the environment and the health risk on human beings.

6. Increasing environmental awareness to identify the dangers of EMP, especially for children. By giving educational sessions to school teachers to promote a culture of environmental protection among school children.

7. Increasing green areas around schools and hospitals to reduce Harmful impacts of EMP in those places.

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