



Evaluation of Electromagnetic Radiation Level in the Outdoor from Wireless Transmission Systems in Northern West Bank – Palestine

تقييم مستويات الاشعاع الكهرومغناطيسي في المناطق الخارجية الصادرة عن أنظمة الارسال اللاسلكية في شمال الضفة الغربية – فلسطين

Mutamed Khatib^{1*}

معمتم الخطيب^{*1}

¹Department of Telecommunication Engineering, Faculty of Engineering, Palestine Technical University- Kadoorie, Tulkarm, Palestine

¹قسم هندسة وتكنولوجيا الاتصالات ، كلية الهندسة ، جامعة فلسطين التقنية-خضوري ، طولكرم ، فلسطين

Received: 16/01/2021

Accepted: 24/02/2021

Published: 30/03/2021

Abstract: Exposure to electromagnetic fields is a major public concern due to the possible hazardous effects on health caused by exposure to these radiations. The aims of this study were to measure radiofrequency radiation levels from different wireless systems and to compare the results with the recommended limits by the World Health Organization (WHO) which should be less than $450 \mu\text{w}/\text{cm}^2$. The study was a cross-sectional study that was conducted in different cities and villages from the northern governorates in the West Bank; Jenin, Tulkarm, Nablus, Qalqilya, Tubas and Salfit. To measure the radiation levels ranging from 80 MHz to 2 GHz, a Portable Field Strength Meter with the suitable set of antennas was used. This frequency range covers the radiations from different sources as mobile phone base stations, local radio and television stations, mobile phones, Wireless Local Area Network, Bluetooth, wireless computer periphery and even microwave ovens. Points close to mobile phone base stations and local radio and television stations in addition to randomly selected points were included. The scanning process for each point was done twice and the higher reading was included in the analysis. The results were compared to the recommended limits of radiations by WHO. Also, a questionnaire was distributed to evaluate people knowledge and perception regarding radiations. A total of 2000 readings were obtained with a mean \pm SD = $0.25 \pm 0.214 \mu\text{w}/\text{cm}^2$. The highest reading was $1.91 \mu\text{w}/\text{cm}^2$. All the readings were below the limits of radiations recommended by the WHO. Most of the readings in the tested area 1184 (59.2%) were between $0.1 - 0.45 \mu\text{w}/\text{cm}^2$ which are 1000- 4500 times less than the maximum allowed level ($450 \mu\text{w}/\text{cm}^2$), 527 (26.35%) readings were $<0.1 \mu\text{w}/\text{cm}^2$, 271 (13.55%) readings were between $0.45 - 1 \mu\text{w}/\text{cm}^2$ and the rest 17 (0.85%) were $>1 \mu\text{w}/\text{cm}^2$ which were still 236- 450 times less than the allowed WHO level. Regarding the questionnaire part, most of the participants use mobile phones frequently, they think radiations are dangerous and can cause cancer, they prefer not to have mobile base stations close to their living places. In this study, a scanning for all electromagnetic radiation sources caused by different sources of wireless communication systems showed theoretically no dangerous radiation levels and all the recorded levels were much lower than the recommended levels by the WHO. Most people feel afraid from radiations and think they are dangerous.

* Corresponding author: m.alkhatib@ptuk.edu.ps

Keywords: Electromagnetic Radiations, Wireless Transmission Systems, Palestine.

المستخلص: يعد التعرض للمجالات الكهرومغناطيسية مصدر قلق عام كبير بسبب الآثار الخطرة المحتملة على الصحة الناتجة عن التعرض لهذه الإشعاعات. تهدف هذه الدراسة الى قياس مستويات إشعاع الترددات الراديوية من أنظمة لاسلكية مختلفة ومقارنة النتائج بالحدود الموصى بها من قبل منظمة الصحة العالمية (WHO) والتي يجب أن تكون أقل من 450 ميغا واط / سم². هذه الدراسة هي عبارة عن دراسة مقطعية أجريت في مدن وقرى مختلفة من محافظات شمال الضفة الغربية، جنين وطولكرم ونابلس وقلقيلية وطوباس وسلفيت. لقياس مستويات الإشعاع التي تتراوح من 80 ميغا هرتز إلى 2 جيجا هرتز، تم استخدام مقياس قوة المجال المحمول مع مجموعة مناسبة من الهوائيات. يغطي نطاق التردد هذا الإشعاعات من مصادر مختلفة مثل محطات الهواتف المحمولة ومحطات الراديو والتلفزيون المحلية والهواتف المحمولة وشبكة الانترنت اللاسلكية والبلوتوث ومحيط الكمبيوتر اللاسلكي وحتى أفران الميكروويف. تم تضمين النقاط القريبة من محطات الهواتف المحمولة ومحطات الإذاعة والتلفزيون المحلية بالإضافة إلى النقاط المختارة عشوائيًا. كما تم إجراء عملية المسح لكل نقطة مرتين وتم تضمين القراءة الأعلى في التحليل. تمت مقارنة النتائج بالحدود الموصى بها للإشعاعات من قبل منظمة الصحة العالمية. كما تم توزيع استبيان لتقييم معرفة الناس وإدراكهم فيما يتعلق بالإشعاعات. تم الحصول على إجمالي 2000 قراءة بمتوسط $SD = 0.25 \pm 0.214 \mu w / cm^2$. كانت أعلى قراءة 1.91 ميغا واط / سم². وكانت جميع القراءات أقل من حدود الإشعاعات التي أوصت بها منظمة الصحة العالمية. حيث ان معظم القراءات في المنطقة المختبرة 1184 (59.2٪) كانت في حدود 0.1-0.45 w / cm² والتي تقل بمقدار 1000-4500 مرة عن الحد الأقصى المسموح به (450 w / cm²)، وكانت 527 (26.35٪) قراءات <math>w / cm^2 < 0.1</math> سم²، 271 (13.55٪) كانت القراءة ما بين 0.45-1 ميكرو واط / سم² والباقي 17 (0.85٪) كانت <math>1 < w / cm^2 < 2</math> والتي كانت لا تزال تقل 236-450 مرة عن مستوى منظمة الصحة العالمية المسموح به. فيما يتعلق بجزء الاستبيان، فإن معظم المشاركين يستخدمون الهواتف المحمولة بشكل متكرر، ويعتقدون أن الإشعاعات خطيرة ويمكن أن تسبب السرطان، ويفضلون عدم وجود محطات قاعدة متنقلة بالقرب من أماكن معيشتهم. في هذه الدراسة، أظهر المسح لجميع مصادر الإشعاع الكهرومغناطيسي الناتجة عن المصادر المختلفة لأنظمة الاتصالات اللاسلكية نظريًا عدم وجود مستويات إشعاع خطيرة وأن جميع المستويات المسجلة كانت أقل بكثير من المستويات الموصى بها من قبل منظمة الصحة العالمية. يشعر معظم الناس بالخوف من الإشعاعات ويعتقدون أنها خطيرة.

الكلمات المفتاحية: الإشعاعات الكهرومغناطيسية، أنظمة الإرسال اللاسلكي، فلسطين.

INTRODUCTION:

The use of wireless systems is increasing more and more. Cellular phones (800-2100MHz), amplitude modulation-AM (550-1720 kHz) and frequency modulation-FM (88-108 MHz) local radio stations, television local stations (54-806MHz), cordless phones (900-928 MHz), walkie talkie systems (136-900 MHz), Wireless Local Area Network-WLAN Routers (2.4, 3.6, 4.9, 5, and 5.9 GHz), Global Positioning Systems-GPS (1575.42 and 1227.60 MHz) and microwave ovens (2,450 MHz) are all considered as sources of Electromagnetic (EM) waves radiation. Many people consider these radiations as a possible cause of serious complications on health as cancer (Moulder JE, Foster KR et al. 2005, Blettner M, Schlehofer B et al. 2009). Due to this possible risk, the World Health Organization (WHO) and Federal Communication committee (FCC) put restrict limitations for the maximum level of radiations that may be harmless for the human beings, based on scientific research in this field (International Commission on Non-Ionizing Radiation Protection 1998, Physicians for safe technology 2020). This radiation level must not be exceed. Most of the wireless systems manufactures ensure that their products do not exceed the

maximum levels of radiations. In our country, some researchers have studied the radiations from mobile communication base stations to evaluate if they are below the limits (Yassin S, Musleh M. et al. 2019). These previous studies have focused on only one radiation source, but in real life, people are affected by radiations from different wireless systems mentioned above, so it is important to evaluate the safety of exposure to all these sources at the same time (Snawder JE 1999). In this study, all wireless systems will be tested at the same time .

Many people all over the world think that exposure to mobile phone base stations and other sources of radiations many cause adverse health effects (Blettner M, Schlehofer B et al. 2009). The epidemiological evidence for a causal association between cancer and radiofrequency (RF) energy is limited. Epidemiologic evidence sometimes show a possible link between exposure to EM field and an increased risk for certain types of cancer (Snawder JE 1999). However, the evidence is limited and more studies are needed (Moulder JE, Foster KR et al. 2005). There is evidence that long term, low level exposure to high frequency EM field may result in a number of symptoms as headaches, fatigue, sleep disorders, memory impairments, they were called "microwave sickness syndrome" (Hutter HP, Moshhammer H et al. 2006). In a previous review, some studies showed increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations (Khurana VG, Hardell L et al. 2010). Surveys among people living close to base stations reported some complaints as sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea and headache. They showed a relationship between the symptoms, the level of exposure, and the distance from base stations (Bortkiewicz A, Zmyślony M et al. 2004). In another study, there was a significant relation between headache and power density. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels, so they concluded that despite very low exposure to HF-EMF, effects on wellbeing cannot be ruled out (Hutter HP, Moshhammer H et al. 2006).

The prevalence headache, memory changes, dizziness, depression and sleep disturbance were significantly higher among people living near mobile phone base stations than controls in a study from Egypt. People near mobile base stations showed significantly lower performance in tests of attention and short-term auditory memory (Abdel-Rassoul G, El-Fateh OA et al. 2007).

In the Palestinian society, there has been great concern about the consequences of radiation on the human health. People have always connected between the increasing number for cancer patients and the radiations, which causes many disturbances when mobile companies want to install new base stations, especially in urban areas or areas close to kids' schools.

Most of the researches that have been done in this field -to remove the fear- are sponsored by mobile companies, which make them not accepted by the public. This study should be considered as a reliable study as it is done and sponsored by third party. The aims of this study were to measure radiofrequency radiation levels from different wireless systems and to compare the results with the recommended limits by the World Health Organization (WHO), in addition to evaluating people knowledge and perception regarding radiations.

MATERIAL AND METHODS:

The study was a cross-sectional study covering an area of about 2000Km² that was conducted in different cities and villages from the northern governorates in the West Bank; Jenin, Tulkarm, Nablus, Qalqilya, Tubas and Salfit in order to determine the dangerous places (if found). The targeted area was shown in **Figure (1)**.

To measure the radiation levels ranging from 80 MHz to 2 GHz, a Portable Field Strength Meter with the suitable set of antennas was used. This frequency range covers the radiations from different sources as mobile phone base stations, local radio and television stations, mobile phones, Wireless Local Area Network, Bluetooth, wireless computer periphery and even microwave ovens. Points close to mobile phone base stations and local radio and television stations in addition to randomly selected points were included.

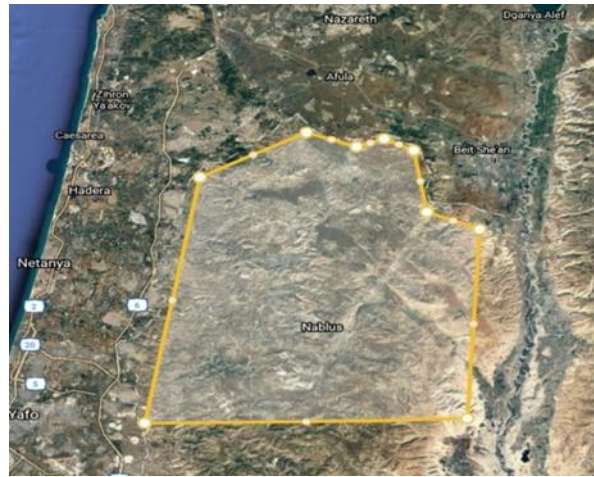


Figure (1): Targeted area of Google maps.

The scanning process for each point was done four times: summer-day, summer-night, winter-day and winter-night, in order to include the weather effects and to ensure that no temporarily disabled system is excluded from the study, the higher reading of the four readings was included in the analysis. The results were compared to the recommended limits of radiations by WHO.

In the second part of the study, a short questionnaire was distributed to evaluate community knowledge and perception regarding radiations. A cross-sectional design was used to collect a convenient sample.

RESULTS:

A total of 2000 readings were obtained from different locations in the targeted area as shown in **Table (1)**, with a mean \pm SD = 0.25 \pm 0.214 μ w/cm². The highest reading was 1.91 μ w/cm².

Table (1): Distribution of tested locations and readings

Governate	Urbans	Locations	Readings
Nablus	46	385	1540
Tulkarm	29	260	1040
Qalqilia	28	228	912

Evaluation of Electromagnetic Radiation level in the Outdoor from Wireless Transmission Systems in Northern West Bank – Palestine

Tubas & North valley	14	409	1636
Salfit	14	282	1128
Jenin	72	436	1744
Total	203	2000	8000

All the readings were below the limits of radiations recommended by the WHO. Most of the readings in the tested area 1184 (59.2%) were between 0.1 -0.45 $\mu\text{w}/\text{cm}^2$ which are 1000- 4500 time less than the maximum allowed level (450 $\mu\text{w}/\text{cm}^2$), 527 (26.35%) readings were <0.1 $\mu\text{w}/\text{cm}^2$, 271 (13.55%) reading were between 0.45-1 $\mu\text{w}/\text{cm}^2$ and the rest 17 (0.85%) were >1 $\mu\text{w}/\text{cm}^2$ which were still 236-450 times less than the allowed WHO level. **Table (2)** and **Figure (2)** summarize these results.

Table (2): Ranges of radiation values from different parts of northern West Bank

Range	Number	Percentage	Ratio < the allowed WHO level
$x < 0.1$	527	26.35%	<4500 $\mu\text{w}/\text{cm}^2$
$0.1 < x < 0.45$	1185	59.25%	1000-45000 $\mu\text{w}/\text{cm}^2$
$0.45 < x < 1$	271	13.55%	450-1000 $\mu\text{w}/\text{cm}^2$
$x > 1$	17	0.85%	236-450 $\mu\text{w}/\text{cm}^2$

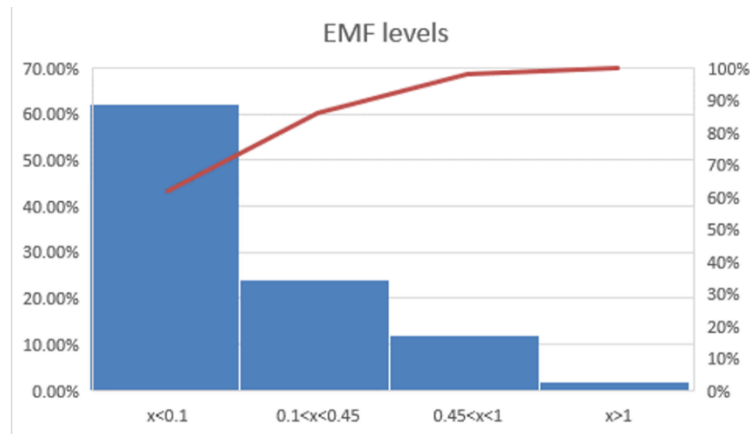


Figure (2): Histogram of radiation values from different parts of northern West Bank

The questionnaire part of the study included 1354 participants, among them 718 (53%) were males, around half of them (52%) were from the age group 18-25 years, most of them (72%) had bachelor degree, 70% of them either strongly agreed or agreed that they use mobile phones several times daily, 91% either strongly agreed or agreed that radiations around us are dangerous, 72% either strongly agreed or agreed that radiations from mobile devices are dangerous. A high percentage of participants thought that radiations from mobile base stations are more dangerous than mobile phones, radiations may cause cancer and that the increase in cancer cases is due to the increased use of mobile phones, so they prefer not to have mobile base stations close to their living places. **Table (3)** below summarizes these results.

Table (3): Response of participants to questions related to EM radiations

Question	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
I use mobile phones several times daily	40	30	25	3	2
Radiations around us are dangerous	62	29	2	6	1

Radiations from mobile devices are dangerous	49	23	15	9	4
Radiations from mobile base stations are more dangerous than mobile phones	59	21	6	4	10
Mobile communication systems may cause cancer	30	35	5	22	8
The increase in cancer cases is due to the increased use of mobile phones	33	39	12	7	9
I prefer not to have mobile base stations close to my living place	42	37	14	6	1
Radiations from mobile communication systems is the major source of environmental pollution	63	18	2	10	7
There is government control over the radiation levels from communication towers	12	15	21	24	28
The level of radiation from the mobile phone is not affected by the distance between you and the service tower	6	9	3	45	37

DISCUSSION:

All the 2000 readings from different cities and villages in the Northern part of the West Bank in this research were lower than the electromagnetic radiation level allowed by the WHO. This is similar to a previous study from Tulkarm city where all the readings were also less than the maximum allowed level (Khatib M 2014). This is similar to some other studies from other countries that measured electromagnetic radiofrequency radiation exposure and found that they were below international limits as in Poland (Gryz K, Karpowicz J et al. 2014), Saudi Arabia (Alhekail ZO, Hadi MA et al. 2012) and most European countries (Gajšek P, Ravazzani P et al. 2015). In an updated systematic review to evaluate the exposure patterns between different types of environments in Europe. Mean outdoor exposure values ranged from 0.07 to 1.27 V/m and RF-EMF exposure levels were highest in the transportation systems followed by outdoor and private indoor environments. They concluded no noticeable increase in everyday RF-EMF exposure since 2012 despite increasing use of wireless communication devices (Jalilian H, Eeftens M et al. 2019). In another updated study from Turkey, RF-EMF measurements were conducted between 2016 and 2018; measurement results were compared with the limit values by Turkey's Information and Communication Technologies Authority (ICTA) and International Commission on Non-Ionizing Radiation Protection (ICNIRP). They found that overall, RF-EMF values did not exceed these limits and they were below levels that threaten public health (Kurnaz C and Mutlu M 2020).

The questionnaire part shows that most of the participants feel afraid from electromagnetic radiations and they think they are a cause of cancer, their fear was mainly from mobile base stations as most of them refused to have them close to their living places. In fact, this topic is complicated because conflicting results can be found. Some reviews show a relationship between EMR exposure and some cancers as brain cancer or leukemia in children, they confirm that more studies with larger sample size are needed (Bielsa-Fernández P and Rodríguez-Martín B 2018). On the other hand, a review from 2019 concluded

that there is no consistent evidence supporting important health effects caused by exposure to low intensities of radiofrequencies among general population (Elwood M and Wood AW 2019). The radiation readings in this study may be used to decrease the fear among the community, the causes of cancer are complicated and studies were not able to find direct connection between allowed levels of electromagnetic radiations around us and cancer. Although more clinical studies are needed, theoretically these levels of radiations are safe.

Regarding other symptoms as headache and loss of concentration, some studies showed that long term, low level exposure to high frequency EM field may result in some symptoms (Bortkiewicz A, Zmyślony M et al. 2004, Hutter HP, Moshammer H et al. 2006, Abdel-Rassoul G, El-Fateh OA et al. 2007, Khurana VG, Hardell L et al. 2010). As these effects cannot be ruled out until more data is available, it is recommended to limit exposure to EM as much as possible specially for children who spend hours on mobile phones and tablets. Most respondents in this study thought that radiations from mobile devices are dangerous. Data about this subject is also inconsistent. Some studies recommend to keep the mobile phones more than 10 cm from the body during calls (Buckus R, Strukcinskiene B et al. 2014) as most public exposure to EM radiations comes from mobiles and wireless portable devices (Gajšek P, Ravazzani P et al. 2015).

CONCLUSION:

In this study, a scanning for all electromagnetic radiation sources caused by different sources of wireless communication systems which covers the commercial communication systems, WiFi, television, FM stations and mobile base stations showed theoretically no dangerous radiation levels and all the recorded levels were much lower than the recommended levels by the WHO. Most people feel afraid from radiations and think they are dangerous.

ACKNOWLEDGEMENTS:

The author would like to thank the Palestinian Ministry of Higher Education and Palestine Technical University-Kadoorie for their financial support to conduct this research.

REFERENCES:

- Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, El-Batanouny M and Salem E (2007). "Neurobehavioral effects among inhabitants around mobile phone base stations." Neurotoxicology **28**(2434-40).
- Alhekail ZO, Hadi MA and Alkanhal MA (2012). "Public safety assessment of electromagnetic radiation exposure from mobile base stations." J Radiol Prot **32**(3): 325-337.
- Bielsa-Fernández P and Rodríguez-Martín B (2018). "Association between radiation from mobile phones and tumour risk in adults." Gac Sani **32**(1): 81-91.
- Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schüz J and Berg-Beckhoff G (2009). "Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany." Occup Environ Med **66**(2): 118-123.
- Bortkiewicz A, Zmysłony M, Szykowska A and Gadzicka E (2004). "Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review." Med Pr **55**(4): 345-351.
- Buckus R, Strukcinskiene B and Raistenskiis J (2014). "The assessment of electromagnetic field radiation exposure for mobile phone users." Vojnosanit Pregl **71**(12): 1138-1143.
- Elwood M and Wood AW (2019). "Health effects of radiofrequency electromagnetic energy." N Z Med J **132**(1501): 64-72.
- Gajšek P, Ravazzani P, Wiart J, Grellier J, Samaras T and Thuróczy G (2015). "Electromagnetic field exposure assessment in Europe radiofrequency fields (10 MHz–6 GHz)." Journal of Exposure Science & Environmental Epidemiology **25**: 37-44.
- Gryz K, Karpowicz J, Leszko W and Zradziński P (2014). "Evaluation of exposure to electromagnetic radiofrequency radiation in the indoor workplace accessible to the public by the use of frequency-selective exposimeters." nt J Occup Med Environ Health **27**(6): 1043–1054.
- Hutter HP, Moshhammer H, Wallner P and Kundi M (2006). "Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations." Occup Environ Med **63**(5307-13).
- International Commission on Non-Ionizing Radiation Protection (1998). "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)." Health Phys **74**: 494-522.
- Jalilian H, Eeftens M, Ziaei M and Röösli M (2019). "Public exposure to radiofrequency electromagnetic fields in everyday microenvironments: An updated systematic review for Europe." Environ Res **176**: 108517.
- Khatib M (2014). "Evaluation of Electromagnetic Radiation Safety from Wireless Transmission Systems in Tulkarm City - Palestine." International Journal of Engineering and Innovative Technology (IJEIT) **3**(10): 38-41.
- Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M and Ahonen M (2010). "Epidemiological evidence for a health risk from mobile phone base stations." Int J Occup Environ Health **16**(3): 263-267.
- Kurnaz C and Mutlu M (2020). "Comprehensive radiofrequency electromagnetic field measurements and assessments: a city center example." Environ Monit Assess **192**: 334.

- Moulder JE, Foster KR, Erdreich LS and McNamee JP (2005). "Mobile phones, mobile phone base stations and cancer: a review. ." Int J Radiat Biol. **81**(3): 189-203.
- Physicians for safe technology. (2020). "Conversion Chart, World Exposure Limits, Human Exposures EMR/EMF." 2021, from <https://mdsafetech.org/conversion-and-exposure-limits-emr-emf/>.
- Snawder JE (1999). "Effect of magnetic field exposure on anchorage-independent growth of a promoter-sensitive mouse epidermal cell line (JB6)." Environ Health Perspect **107**(3): 195-198.
- Yassin S, Musleh M. and Abuzerr S (2019). "Electromagnetic Radiation Exposure from Nearby Cellular Base Stations in the Gaza Strip, Palestine: ." A Concern for Public Health. Journal of Biosciences and Medicines **7**: 46-59.