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Measurement and assessment of mobile network electromagnetic radiation pollution in Ramadi, Iraq

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ABSTRACT

The electromagnetic radiation produced by cellular towers in Ramadi city, west of Iraq, is measured and analyzed in this research. This contains basic nodes, hub repeaters, and feeders for transmitting the carrier throughout the entire Ramadi city as well as the surrounding areas. As a result, this research focused on this area to measure and assess energy to determine if it is safe for people or has over the danger threshold. The study region was split into fifty-five mobile phone tower locations. In general, electric field intensity levels surpass 1.7 V/m, which is dangerous and should be reduced. However, apart from a few sites (2, 3, 35, 36, 45, 51, and 53), the magnetic field intensity and radiation density are acceptable based on the findings. The energy severity criteria are based on LATNEX corporation's guidelines.

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1. INTRODUCTION

Electromagnetic structure that exists in nature are created by the toiletries or within and external sources, for instance, charges discharged onto the earth as well as radiation emitted from space [1]. The frequency range of natural electromagnetic is broad, accompanied by high rates of transients and voltages that are sharp-edged produced by varied conditions. Natural background is a structure that is less or less strong than that generated by manufactured radio frequency (RF) radiators. Usage of equipment, systems, and devices which create high-frequency electromagnetic radiation is quickly rising. In military, medical appliances, and specialized sites and labs, sources, which create high quantities of electromagnetic radiation, are commonly encountered. A variety of medical devices are used for a variety of purposes. Magnetic resonance imaging (MRI), hyperthermia, diathermic, and RF excisions are all possible methods that can emit a significant amount of electromagnetic radiation near or inside the patients, which will risk exposing patients to greater levels of radiation. In addition, certain types of healthcare equipment may emit significant levels of radiation in particular areas [2], [3]. To expose additional zones to RF radiation, the power of the RF radiation must be increased. The electric field's amplitude can reach kV/m. The manufacture of various tools from heat supply and the many foundations utilized for the creation of plasma discharges in the material account for a large portion of the value. The medical and safety difficulties of high-power RF are rising because of their widespread usage by industry, particularly because encapsulating electromagnetic fields (EMF) conductors is challenging [4]-[6]. In today's world, television broadcasting, cellular communication networks, internet broadcasting, and other forms of electromagnetic radiation may create high amounts of electromagnetic radiation in public spaces. Multiple cell phone-related gadgets, in any case, may generate ostensibly high peak exposure levels when in use [7]. Numerous researchers have been conducted on the radiation effects on the skin of rats [8], plant properties, deoxyribonucleic acid (DNA) characteristics, pharmacological stabilization, the cells of the hair follicles in the ear canal, brain, fertility of sperm, child development, public health, and organisms' physiological systems [9]. Despite all the medical concerns, it is currently being investigated to see if a certain radiation frequency causes sickness or other medical difficulties [10]. Detection of boundary conditions for any devices or applications with relatively high levels of radiation is essential. As a result, the relevant authorities will have a complete understanding of current issues [11].

2. METHOD

The study was based on a random selection of an Iraqi city. The evaluation will take place in Ramadi City, which has a dense population of 223,500 people. The study is set up by randomly selecting and distributing venues [12]. All of Ramadi's communities and regions are covered by these points. The numbers for the electromagnetic parameters were recorded in real time. Because the sun produces a wide band of frequencies during daylight, the measurements are conducted after sundown [13]. In each urban or residential region, there are electromagnetic radiation guidelines that readings should not exceed. Many medical, environmental, and technological concerns, as well as survey results, went into the development of these standards. As stated previously in this study, there is a risk of developing medical problems because of radiation absorbed by live tissues and its harmful effects [14]. Some of the communication towers used in Ramadi are depicted in Figure 1. Because the waves pass through the walls of buildings, measurements were collected from the interior of the occupied structures. Another purpose is to detect the strength of radiation emitted by routers and other broadcasting equipment [15].

Previous studies have focused on the temperature or thermal effects of radiation. To put it another way, the amount to which radiation, like a heat kiln, may warm tissues or "cook dinner" someone within. Heights may also protect our tissues from becoming overheated, but they fail to account for continuous, long-term exposure at low levels, known as non-thermal effects [16]-[19]. RF radiation, according to doctors, is interfering with the regular activities of biological cells. Dr. George Carlo, an epidemiologist who discovered genetic harm in a $28 million industry-funded study effort, adds, "RF affects tissue physiology." He is now fighting to reduce safety standards. The Vienna Resolution, signed by 16 of the world's best bio electromagnetic researchers in 1998, presented a consensus declaration that the biological consequences of low-intensity RF exposure have been established. Existing scientific information, it claims, is insufficient for establishing reasonable exposure standards [20].

Figure 1. Public communication towers in Ramadi city

3. MEASUREMENT TOOL

The measuring instrument is the LANTEX corporation's triple axis RF/high-frequency meter HF-B3G. The purpose of this meter is to measure and monitor the strength of radio-frequency electromagnetic fields. Over a frequency range of 50 MHz to 3.5 GHz, the meter is properly calibrated. There is a current or voltage, magnetic field (H), or electric field (E) arises, there is artificially generated electromagnetic pollution that is measured by the device. Electromagnetic fields are generated by a variety of sources, including cell towers, television transmitters, radio broadcasting equipment, and they may be found virtually anywhere that affects the biological environment, even if our bodies are unable to detect them. To assess (RF) radiation, there are three primary measurements [21]-[23]:

– Electric field strength (E): the force (F) on an infinitesimal unit positive test charge (q) at a location split by that charge is represented as a field vector quantity. This device directly detects the electric field strength, which is measured in volts per meter (V/m) [24].
– Magnetic field strength (H): the portion of a material's magnetic field that derives from an external current and is not intrinsic to the material itself, also known as magnetic intensity or magnetic field intensity. It is denoted by the letter H and is measured in amperes per meter (A/m) [25].
– The power density (S): the power flux density, abbreviated as I, is the power per unit area normal to the electromagnetic wave propagation direction. The power flux density, generally measured in watts per square metre (W/m^2), is the power per unit area normal to the propagation direction of electromagnetic waves [24].

4. RESULTS AND DISCUSSION

This article measures and evaluates the radiation level emitted by towers of communication in Ramadi. Ramadi is the capital of Anbar province, which has a dense network of broadcasting and communication towers, making it an ideal case study location. Figure 2 depicts a top view of the city with the scanned measured places. The locations are chosen with care, based on a map of the city's communication tower distribution. The scanned area's population distribution is recorded to assess the radiation intensity near essential places, including schools, mosques, bazaars, and hospitals [26]. Fifty-five locations, where mobile towers are placed have been measured to determine whether they are safe. It is observed that in many cases, the electric field (E) intensity measurements are found to be dangerous and thus must be addressed. According to LATNEX corporation's radiation severity standards: they surpass the level of 1700 mV/m. The measurements of the radiation density and magnetic field strength, however, are acceptable except for these places (2, 3, 35, 36, 45, 51, and 53).

Figure 2. Topview Google map of Ramadi city and test locations

The bandwidth on which the study was based ranges from 50 MHz to 3.5 GHz. Cellular networks, internet broadcastings, Wi-Fi gadgets, wireless local area network (WLAN), and other potential sources of electromagnetic radiation are therefore considered. Due to utilizing the applications, most people are exposed to an extended dose of radiation for a considerable period [27]. As previously stated, the results were held in Ramadi city in arbitrarily, somehow, uniformly dispersed picked spots. The electromagnetic field dispersion findings are shown in Table 1.

Table 1. Electromagnetic radiation for each location

Location No.	Electric Field(m V/m)	Magnetic field (m A/m)	Power density (μ W/cm^2)
1	785	2.21	0.205
2	6350	11.63	4.413
3	8390	15.47	6.395
4	1125	3.45	0.251
5	455	1.39	0.051
6	935	2.51	0.075
7	883	2.32	0.107
8	268	1.092	0.021
9	868	2.84	0.156
10	878	2.37	0.145
11	730	2.15	0.124
12	852	2.34	0.135
13	942	2.67	0.145
14	273	0.541	0.005
15	73	0.116	0.003
16	1255	2.97	0.348
17	509	1.445	0.044
18	1229	2.89	0.161
19	534	1.344	0.042
20	1082	2.32	0.144
21	255	0.512	0.007
22	858	2.65	0.127
23	1405	3.27	0.387
24	572	1.843	0.067
25	733	2.71	0.088
26	122	0.328	0.002
27	1236	3.2	0.217
28	776	2.57	0.138
29	1057	3.64	0.225
30	1143	2.52	0.172
31	1167	3.46	0.254
32	1083	7.67	0.311
33	903	2.31	0.174
34	439	1.227	0.018
35	1814	45.23	63.457
36	10814	27.52	21.974
37	823	2.27	0.131
38	1022	2.39	0.227
39	1176	2.96	0.198
40	1022	2.48	0.157
41	622	1.461	0.041
42	566	2.28	0.105
43	1242	3.85	0.388
44	720	1.904	0.092
45	4620	12.51	4.732
46	1016	2.82	0.166
47	1237	3.53	0.286
48	1347	3.59	0.368
49	1067	2.75	0.213
50	1072	3.11	0.127
51	17653	41.09	47.131
52	1174	3.06	0.244
53	6756	11.425	2.243
54	1284	2.764	0.152
55	1259	3.066	0.205

As seen in the table, the values are higher in more general than the suggested levels for each RF band (1). The EMF radiation has contaminated the entire ecosystem. The distribution of electric and magnetic fields in the assigned region is also depicted in Table 1. Except for the sites listed below, magnetic field radiation is under the acceptable threshold of safety (2, 3, 35, 36, 45, 51, and 53). Some radiation density measurements are outside of the acceptable range, and immediate action is needed to bring these dangerous values back into the safe range. The radiation at 36 is quite dangerous. Because the region is the countryside and the transmitted strength is within the acceptable threshold, there are certain spots (14, 15, 21, and 26) with low radiation. The recorded radiation intensity levels range from 1 to 100 W/cm^2. In comparison to other nations, it has one of the lowest levels of protection [28]. The information gathered at Ramadi sites meets current European and American standards. Australia's guidelines, on the other hand, are 5 times lower, at 20 W/cm^2. Furthermore, the requirements in Russia, Italy, and Canada are ten times lower, at 10 W/cm^2. China has a score of 6, while the Swiss have a score of 4. The level is 0.1 (pulsed) in Salzburg, Austria, which is 1,000 times lower than Ramadi. New Zealand has recommended even higher protection levels, at 0.02, which is 5,000 times higher. N indicates normal while E indicates the excessive radiation value, Table 2 compares to international standards.

Table 2. Comparison of Ramadi radiation intensity with standards in other countries

Location	USA	EU	Australia	Russia	China	Swiss	Austria	NZ	LATNEX
1, 4, 5, 6, and 7	N	N	N	N	N	N	E	E	E
2	N	N	N	N	N	E	E	E	E
3	N	N	N	N	E	E	E	E	E
8, 17, and 19	N	N	N	N	N	N	N	E	E
9, 10, 11, 12, and 13	N	N	N	N	N	N	E	E	E
14, 15, and 21	N	N	N	N	N	N	N	N	E
16, 18, 20, 22, and 23	N	N	N	N	N	N	E	E	E
24, 25, 26, and 27	N	N	N	N	N	N	N	E	E
28, 29, 30, 31, 32, 33, and 34	N	N	N	N	N	N	E	E	E
35 and 36	N	N	E	E	E	E	E	E	E
37, 38, 39, and 40	N	N	N	N	N	N	E	E	E
41, 34, and 44	N	N	N	N	N	N	N	E	E
42	N	N	N	N	N	N	E	E	E
45 and 53	N	N	N	N	N	E	E	E	E
46, 47, 48, 49, and 50	N	N	N	N	N	N	E	E	E
51	N	N	E	E	E	E	E	E	E
52, 54, and 55	N	N	N	N	N	N	E	E	E

5. SPECIFIC ABSORPTION RATE

Local agents in industrialized nations try to reduce the amount of radiation that may be received once a mobile phone is placed directly into the user's ear. As a result, before entering the market, the phone must pass the specific absorption rate (SAR) requirements test. SAR is a measure of how much vigor is immersed in the human skull once the phone or other technology has been given complete control. SAR is a measure of absorbed energy resulting from a little amount of tissue (1 gram in the United States and 10 grams in Europe). In (1) accurately represents SAR.

$$SAR = \int \frac{\sigma(r)|E(r)|^2}{\rho(r)} dr \qquad (1)$$

Where: $\sigma(r)$ material conductivity (S/m)
$E(r)$ electric field (V/m)
$\rho(r)$ mass density (kg/m^3)

- $\sigma(r)$: the SAR is determined by measuring the material's electric conductivity (the brain tissue and typically) siemens/m is a unit of measure of conductivity. In this context, electric conductivity refers to how rapidly a substance turns an electric field into heat.
- $\rho\ (r)$: it is the material's mass density that is being measured. The density is expressed in kilograms per cubic meter (kg/m^3) or grams per cubic centimetre (g/cm^3). The electric field as a function of location is denoted by E (r), where r is the position vector. Finally, V is the volume that the SAR is calculated across.

As a result, (1) may be rephrased as follows: SAR it is the weight of the material in a particular area divided by the degree of common warmth absorbed in that region. Thus, SAR is measured in watts per kilogram (Watts/kg) or mW/g. Many international and governmental organizations are working to keep the value of SARs under control. The Federal Communications Commission (FCC), for example, establishes the tight SAR limitation in the United States. This regulation states that a mobile phone's SAR cannot exceed 1600 mW/g (1.6 W/kg) while transmitting at maximum power at any frequency. They demand that the "averaging" be done across a volume of tissue with a mass of 1 gram. SAR must be measured across 10 grams in Europe, and the maximum value is 2000 mW/g (2 W/kg). The SAR test is significantly simpler to pass in Europe since the limit is greater numerically and average over a bigger volume. This is since as soon as an electric field penetrates human tissue, it immediately dissipates. Consequently, averaging across a greater volume lowers the average electric field, making the specification far more manageable. As a result, the US SAR standard is far stricter than the rest of the globe. According to the Frey report, the SAR value of the chosen locations cannot exceed 1.6 (W/kg). Regarding the radiation density, the highest value we have ever measured is around 63.231 W/cm^2, whereas the suggested maximum value is around 400 μW/cm^2. In fact, LATEX corporation advises against exceeding 0.003 μW/cm^2.

6. MAXIMUM PERMISSIBLE EXPOSURE

There are many government agencies that have established exposure limits maximum permissible exposure (MPEs) and RF radiation exposure threshold values MPEs and guidelines, such as National Council on Radiation Protection and Measurements (NCRP), American Conference of Governmental Industrial Hygienists (ACGIH), American National Standards Institute (ANSI/IEEE), Occupational Safety and Health Administration (OSHA, FCC, Environmental Protection Agency (EPA), Food and Drug Administration (FDA), and National Institute for Occupational Safety & Health (NIOSH). Most RF safety limitations are expressed as electric and magnetic field intensities as well as power density. The limitations are more easily represented as electric and magnetic field strength values at lower frequencies. It is illustrated in Table 3 that exposure is characterized as power density for transmitters operating from 300 kHz to 100 GHz.

Table 3. IEEE limits for occupational/controlled exposure MPES

Frequency	Power Density (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength H (A/m)
30 kHz–100 kHz		614	163
100 kHz–3 MHz		614	16.3/f
3 MHz–30 MHz		1842/f	16.3/f
30 MHz–100 MHz		61.4	16.3/f
100 MHz–300 MHz	1	61.4	0.163
300 MHz–3 GHz	f/300		
3 GHz–15 GHz	10		
15 GHz–300 GHz	10		

MPE limits are calculated over a period. It is permissible to exceed the MPE for short periods of time if the average exposure over a reasonable amount of time (e.g., 6 minutes) does not exceed the MPE. It's worth noting that the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines set lower limitations than the ones listed in the IEEE chart. For public health reasons, lower limits are set for non-occupational exposure. The FCC defines restrictions in SAR for limited partial-body exposures (such as cell phones in Table 4 [29].

Table 4. FCC limits for SAR for partial exposure

Occupational/Controlled Exposure	General/Uncontrolled Exposure
(100 kHz–6 GHz)	(100 kHz–GHz)
< 0.4 W/kg whole-body	< 0.08 W/kg whole-body
≤ 8 W/kg partial-body	≤ 1.6 W/kg partial-body

7. CONCLUSION

In this study, the electric field (E), magnetic field (H), and power density measurements in Ramadi city are utilized to evaluate the electromagnetic radiation. Although the EMF intensity is controversial, the Australian standard is highly recommended to be the level to evaluate the Iraqi EMF radiation values. The observations show that Iraqi rules for EMF controlling, and regulation need to be reevaluated. Several locations have been recorded with elevated radiation values, while the rest were within the acceptable range based on the global standerds. Consequently, the observed values are high; therefore, the urgent action must be taken to mitigate the excessive values of electric and magnetic field intensity, particularly in locations (3, 35, 36, 45, and 51), which are very polluted locations. It appears that radiation density can be considered safe up to a level of 400 μW/cm^2. Few sites (14, 15, 21, and 26) recorded low radiation values compared to others due to the low level of emitted power. The study shows that EMF intensity values in Ramadi are 1-100 μ W/cm^2. Comparing with the other countries' standards, Ramadi is among the cities, which have least protective in the world. Contrary to what the communications industry claims, epidemiological and medical research shows that long-term exposure to mobile and internet EMF, as well as microwave radiation produced from communication towers, can have negative impacts on biological systems, even at low levels.

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