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RESEARCH ARTICLE

Electromagnetic Field Pollution Level Measurement for Mobile Phone Networks at Cihan University-Erbil

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ABSTRACT

The health effects of the impact of radiofrequency (RF) electromagnetic fields (EMF) have become of increasing concern. We conducted a specific absorption rate (SAR) study and measurements of wireless and mobile phone networks to evaluate the hazard of RF radiation limit. Our measurements have been carried out at different locations on the campus of Cihan University-Erbil. The RF strength level measurement of a base station on site was done by using a spectrum analyzer with a dipole antenna and electromagnetic field detector (EMF) application in the handsets for mobile networks, then comparing our measurements with the international slandered SAR levels.

Keywords: Antenna, electromagnetic fields pollution, mobile network, specific absorption rate limit, Specific absorption rate

INTRODUCTION

For more than many years, most people have been concerned about the possible health consequences of exposure to radiofrequency radiation (RF and mobile devices). Excessive levels of RF fields are known to induce various physical effects on the human body. Today, after the wide variety boom in public use of wireless devices, especially cell phone networks, it has emerged as obligatory to ensure that these products no longer divulge their users to potentially harmful degrees. At the frequencies at which the maximum of these devices operate, the acknowledged health outcomes are middle on or around tissue heating.

SPECIFIC ABSORPTION RATE (SAR) AND SAR LIMITS

SAR is referred to as the specific absorption rate and is the time byproduct of the incremental energy (dW) absorbed or dissipated in the incremental mass (dm) contained in an amount (dV) of a given density (ρ):[1]

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{pdV}\right) \tag{1}$$

SAR should be considered an "absorbed dose rate" and is related to electric fields at a point by:

$$SAR = \frac{\sigma\left|E\right|^2}{\rho} \tag{2}$$

Where:
σ = Conductivity of the tissue (S/m)
ρ = Mass density of the tissue (kg/m^3)
E = Root mean square (rms) of electric field strength (V/m).

The bounds, which apply in widespread for cell phones and similar apparatus, there are two limits in every one of them a low rate for exposure averaged over all frames and a higher rate relevant to nearby publicity to components of the body. This partial-frame SAR is averaged over a quantity of tissue defined as a tissue volume within the form of dice. American necessities differ from the global requirements of their call for lower spatial joint restriction, which is the typical limit over a smaller quantity (1 g of tissue as opposed to 10 g). In addition, they require an extended time over which the SAR is to be averaged. Still, for the reason that it is miles assumed that a person with the portable tool will be uncovered to the maximum power available from the device during the required average time, the required time averaging of the output all through SAR size does not require practice.

The ANSI/IEEE and ICNIRP published RF publicity limits measures that must no longer be handed to human health. The ANSI/IEEE limits the spatial-average special absorption rate (SAR) to at least one. 6 W/kg over 1 g of tissue over half-hour.[2]

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In addition, the ICNIRP limits the SAR to 2-four W/kg.[3] Mobile telephones commonly have a time-averaged energy output of 600 mWatt or much less and yield numerically modeled mind SARs which might now and again exceed 1.6 W/kg restriction; however, which commonly lie inside the ANSI/IEEE "managed surroundings" condition of 8W/kg averaged over 6 min. The following Table 1 represents the international fashionable used for measuring SAR restriction.

MOBILE PHONE NETWORKS

The cellular smartphone era consists of the essential components: The provider and the consumer. The bottom stations (BS) are on the provider side, "the antenna distribution on the towers which speak with the mobile phones." On the consumer side is cell smartphone handsets. Base stations BS emit electromagnetic radiation continuously and at some distance extra strength than cell phones which emit electromagnetic radiation continuously simplest all through calls or makes use of information. In the rest of the instances, that is, idle mode, mobile phones emit a regular pulse of electromagnetic radiation for base stations to continuously preserve track of the geographic role of the telephones in their "cell community." Modern-day 2nd era (2G) BS antennas are associated with transmitter powers of 20 – a hundred Watt, despite the fact that the ultra-modern 3rd era (3G) BS antenna use much less electricity, on average 3 Watt in city regions. In rural areas, the BS power output is much better due to the many regions that need to be included between base stations positioned in far-off places.

By implementing Urban sprawl strategies, technology has advanced and the data demands of cellular networks have increased, the number of towers has increased significantly, but companies have made little effort to share such towers. Although the number of antennas in our urban environment is low, the increased number of antennas has improved cell phone reception in moving elevators, large building centers and basements, and other "dead" locations. The ability of a mobile phone user to be instantly "discovered" by a base station almost anywhere on the planet is astonishing, and the widespread current should show nearly prevalent generation and propagation. Network,[5] and a new generation of mobile networks Evolved Node B (eNB).[6]

MOBILE ANTENNAS AND ANTENNA ARRAYS

Antennas generally have a specific directivity. An omnidirectional antenna radiates in all directions (horizontally viewed), whereas a sector antenna effectively radiates in only one (horizontal) sector [Figure 1].

This allows more spectrum reuse due to less interference. Therefore, most base stations in congested areas such as cities are sectoral. The recommended gain for sector antennas is 10–20 dBi. This means that the radiated power in the direction of interest can be 10–100 times stronger than an Omni antenna but correspondingly weaker in other laws.[7]

Table 1: SAR limit guideline[4]

Guideline	SAR limit - Head, neck, and trunk
Health Canada Safety Code	1.6 W/kg averaged over 1 g of tissue
Europe	2.0 W/kg average over any 10 g of tissue
Australia	1.6 W/kg averaged over 1 g of tissue
US	1.6 W/kg averaged over 1 g of tissue
India	1.6 W/kg averaged over 1 g of tissue
ICNIRP	2.0 W/kg average over any 10 g of tissue

SAR: Specific absorption rate

MASSIVE MULTI INPUT MULTI OUTPUT (MIMO) ANTENNA ARRAYS

Massive MIMO antenna array is a recent application in 5th mobile networks (5G) and beyond, which supports the sub 6 GHz frequency as well as millimeter wave (mmWave) radio frequencies,[8] nowadays mmwave massive MIMO antennas serving frequencies below 100 GHz but it can reach up to 300 GHz or even Terra Hertz frequency band shortly. The main advantage of Massive MIMO is the ability to serve multiple users and multiple devices simultaneously within a condensed area by very narrow beam by deploying beamforming technology[8] Figure 2; due to the high gain of these antennas, a meager power can be transmitted from the base stations compare to

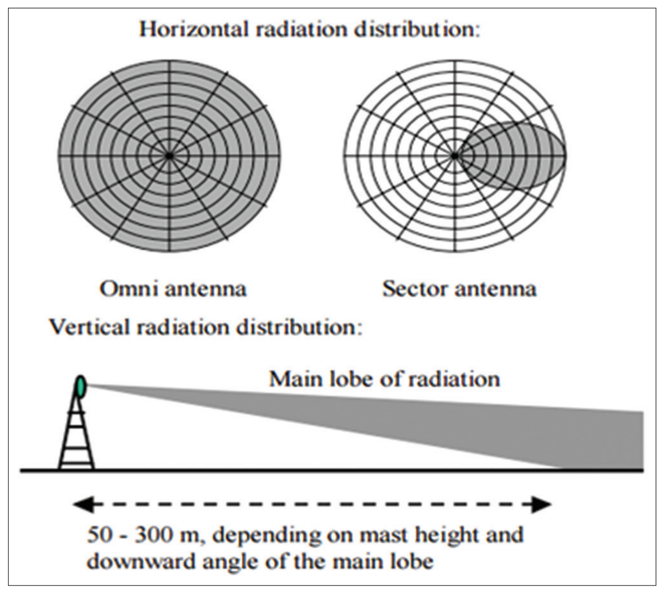

Figure 1: Antenna radiating for mobile base station

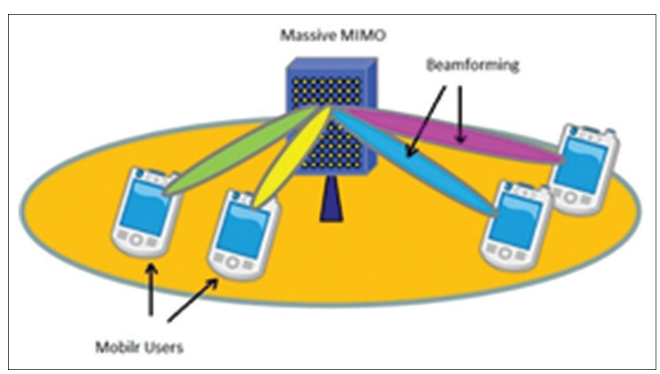

Figure 2: Massive multi input multi output beamforming

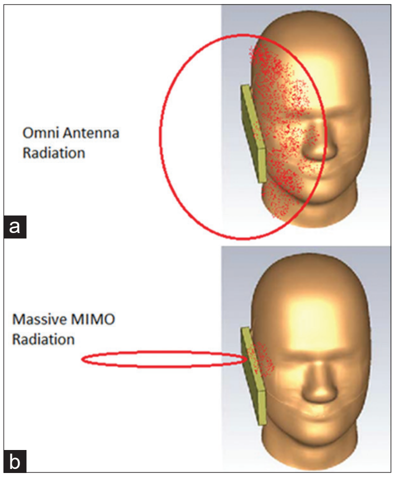

Figure 3: Antenna radiation pattern for mobile handsets, (a) omnidirectional antenna, (b) massive multi input multi output antenna beamforming toward the bottom stations

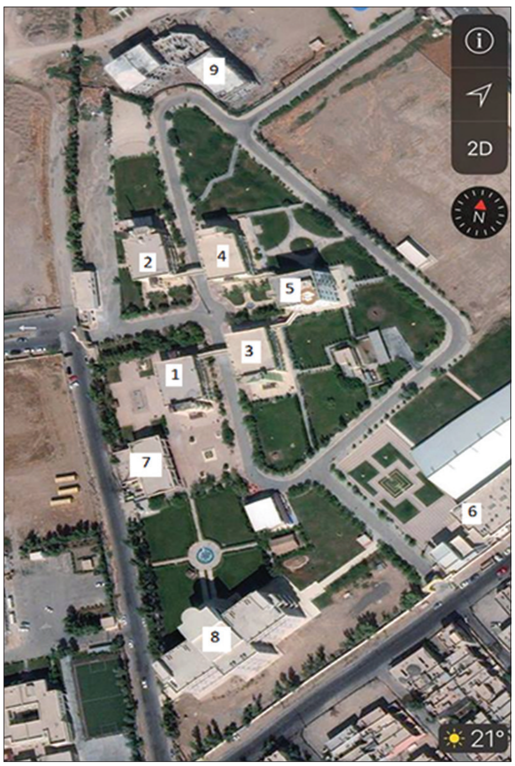

Figure 4: Site of Cihan University-Erbil

conventional omnidirectional antennas, furthermore only the mobile users will be reached with BS transmission. At the same time, they are active users (in call or data stream use), which could be a significant improvement to reduce EMF pollution and lead to reduce SAR in public areas, see Figure 3, on the other hand, massive MIMO has become an exciting candidate to improve the mobile handsets[9,10] in the same way to reduce transmission power directed to the BS with compare to omnidirectional antennas which transmitting almost in all directions, so overall massive MIMO technology is an improvement to reduce SAR at both BS and mobile handsets.

Table 2: Strength measurement and SAR calculated at Cihan University-Erbil

Location	Power (dBm)	Sar
Building 1	-76	1.13638E-09
Building 2	-76	1.13638E-09
Building 3	-86	1.13638E-10
Building 4	-80	4.524E-10
Building 5	-85	1.43061E-10
Building 6	-71	3.59354E-09
Cafeteria	-66	1.13638E-08
Building 8	-68	7.17006E-09
Building 9	-74	1.80104E-09
Research center	-63	2.26737E-08

MEASURING SAR LEVEL IN CIHAN UNIVERSITY-ERBIL

At the Cihan University campus, there are nine buildings as shown in Figure 4. The Mobile base station is allocated on the top of building 5, which has four floors with an additional room on the top; buildings 1, 2, 3, and 4 have three floors, and building 8 and 9 have four floors.

The measurement has been taken using a Tektronix spectrum analyzer covering a frequency band up to 1GHz, connected to a dipole antenna that matches the downlink frequency to measure the power level in dBm at several locations. To duplicate and confirm, our measurements a mobile application been used to indicate the power levels as well. The application which called mobile network EMR application was used to measure that strength level from designated base station.

Table 2 shows the power levels measured in dBm and SAR calculated values at different locations (buildings) in the university.

Using equation (2) to calculate SAR, it is assumed the average parameters for that conductivity of the tissue $\sigma = 150$ (S/m), and mass density of the tissue $\rho = 1250$ (kg/m^3), the electric field intensity E is determined from (3),[11] where η is the free space characteristic impedance $= 120\ \pi\ \Omega \approx 377\ \Omega$ and S is power density

$$E^2 = S.\eta \tag{3}$$

According to the measurements and calculation the highest SAR level at building 8 and research center, which is about 7.17×10^{-9} w/kg, and it is considered too small comparing to the international standard.

CONCLUSION

The work shows that there are many factors effect on the SAR level, it can be summarized by two main parts, first on the base station parameters (power transmit, antenna types, antenna installing angles, and the distance), and the second part is the body mass and time can be explosion from that radiation.

At Cihan University-Erbil campus, the measurement proves that the SAR level for the mobile base station operating onsite is below the standard SAR limit value and it will not be considered as hazard. Meanwhile; we believe the radiation from mobile handsets results higher SAR level to the users when they are in call or data usages comparing to the SAR level from base station at Cihan University.

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