SETSCI Conference Indexing System,
Volume 3 (2018), 510-513

ISAS 2018-Winter
2nd International Symposium on Innovative Approaches in Scientific Studies
November 30 – December 2, 2018, Samsun, Turkey

Radiation Exposure Level Identification of Cellular Phone in Standby Mode

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Presentation/Paper Type: Oral / Full paper

Abstract – Cellular phones are playing an important role in technological devices in today's world. People start to use cellular phones at early ages. Even kids have their own cellular phones as a precaution for their security. However, researches evaluating long term use of cellular phones on safety of humans in respect of radiation emitted from cellular phones have not completed yet. Until these researches are concluded, users of cellular phones should be prudent not to be much exposed to its radiation. In this context, there are some advices from experts to minimize radiation exposure level of cellular phone such as using headset while speaking, sending SMS instead of speaking if it is possible, and turning it off while sleeping at night. In this study, it is aimed to show the effect of staying cellular phone in standby mode on radiation exposure level sleeping in bedroom at night. For this purpose, some measurements were carried out with Narda EMR-300 radiation meter which has a capability of measuring total electromagnetic radiation level from 100 kHz to 3 GHz frequency. Recorded values are compared with national and international limit values determined by International Commission on Non-Ionizing Radiation Protection (ICNIRP).

Keywords – Cellular Phone, Electromagnetic Radiation, Measurement, Health, Bedroom.

I. Introduction

In recent years, communication sector has been a high growth rate especially in area of cellular phones. Cellular phones have become indispensable communication tool in daily life. With proliferation of smartphones, phones can be used as a communication device besides a computer. For this reason, people may come up with an idea related to cellular phone addiction [1]. With technological development, many health problems caused by RF electromagnetic fields generated with cellular communication devices have increased day by day. Cellular phones are devices which can generate electromagnetic waves in all directions. These waves are absorbed by people and converted into thermal energy. Thus, health problems can be occurred in regions which exposed to electromagnetic radiation for a long time. It also can be caused that there are concerns about eye health and posture disorders [2], as well as health problems caused by electromagnetic radiation which are not known yet [3]. Therefore, it is very important to present level of radiation emitted by cellular phone in scientific research.

The effects of electromagnetic radiation (EMR) on human health have been important subject of research from past to present. Although level of radiation produced by cellular phones is within limits of EMR, various diseases such as migraine, liver damage and brain tumor have emerged from the pilots exposed to this radiation [4]. In contrast to this thesis, it has been suggested that radiation generated by cellular phone is not related to glioma and meningioma diseases [5]. Kumar et al. conducted a study on attenuation of incoming radiation for different cellular phone antennas (monopoly, double-layered double PIFA, dual BIFA and rear-positioned PIFA antenna) [6]. It has been observed that efficiency of shielding effect is increased as aluminum ratio is increased in non-conductive polymers with aluminum particles. Chou et al. showed that theoretical and numerical calculations about Specific Absorption Rate (SAR) value created by a cellular phone with monopoly antenna can be reduced by shielding [7]. Fung et al. evaluated SAR values of different model cellular phones and analyzed activities of commercially available cellular phone screenings. Cheng et al. revealed relationship of SAR values with conductivity of cellular phone user garments by numerical analysis with Finite Difference Time Domain (FDTD) [8].

In case of 1 S / m conductivity for 900 MHz, SAR value was found to fall below 1.08W / kg to 0.2W / kg [9]. The cellular phone service providers in Turkey, which are Turkcell and Vodafone operating at 900 MHz and Turk Telekom operating at 1800 MHz, have two different frequencies [10-15]. These frequency of electromagnetic wave affects human body varies according to frequency; cellular phones used at 900 MHz have more effect on body than at 1800 MHz. As a result of research done so far, use of cellular phones is not a danger to human health. However, this does not mean that use of cellular phones has no harm to health. The effects of using cellular phones are likely to occur in coming years. Therefore, limit values for each frequency are determined for electromagnetic wave intensity exposed. The limit values are determined by competent authorities of each country. Therefore, some countries have shown more sensitivity and have lower values than other countries. These values, which may vary between countries, are determined separately for uncontrolled regions that general population can enter and for controlled regions where only professional workers are located. The reason is that boundary values are

different for public and workers. Public can be unaware of necessary protective measures because they will be ignorant about this issue. The limit values in uncontrolled region were kept to a lower level. The limit values must be complied with in Turkey ICNIRP by Telecommunications Authority (International Commission on Non-Ionizing Radiation Protection) data 41.25 V/m for the electric field in the 900 MHz frequency in an uncontrolled area based, in the 1800 MHz frequency 58.34 V / m respectively.

SAR values were taken into account when determining these limit values. SAR is the rate at which the body absorbs electromagnetic wave. The studies conducted so far show that human body cannot regulate temperature increase and cause problems. The human body needs to absorb 4W power per kilogram for a temperature increase. The SAR limit of 0.08W / kg, which is 1/50 of this value, has been accepted in the general habitats of people. SAR is almost impossible to measure directly. Therefore, parameters that can be measured and / or observed easily are used to determine limit values. These parameters are electric field strength, magnetic field strength and power density. For this purpose, exposure of cellular phone with standby mode in bedroom was investigated in this study. This paper organized with material and methods part in Section II. There are results and discussion part in Section III. Finally, conclusion part is in Section IV.

II. Materials and Method

Determination of EMR exposure level can be realized by electromagnetic software or real-time measurements. For this reason, it is firstly necessary to explain the electromagnetic wave propagation and mathematical expressions.

A. Theory of Electromagnetic Radiation (EMR)

When EMR was evaluated in free space, it was determined that photons formed at speed of light with increasing frequency. EMR expression is used to identify electromagnetic waves that are radiated or propagated in free space.

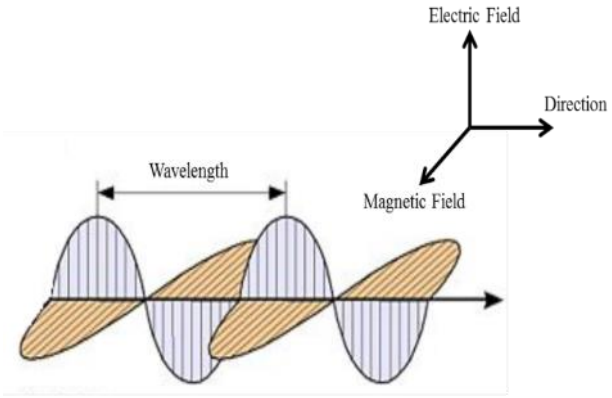


Fig. 1 EMR Schematic

As seen in Fig. 1, magnetic field components are perpendicular to electric field in electromagnetic wave. The locus of wave is determined by wavelength or frequency. When particles with load on them are accelerated by an external source, they produce an electromagnetic wave. Depending on duration and intensity of EMR exposure, SAR values may vary. Where electric field is defined as E, radiation power from is symbolized as P at distance d. Instantaneous energy density is calculated as $u_E=(1/2).\varepsilon_0 E^2 c$.

$$\frac{P}{4\pi d^2}=\frac{1}{2}\varepsilon_0 E^2 c \tag{1}$$

c is electromagnetic radiation speed. ε_0 represents permittivity of free space. E is obtained as in Eq. 2.

$$E=\left[\frac{P}{2\pi\varepsilon_0 c d^2}\right]^{1/2} \tag{2}$$

c is assigned as $3x10^8$ m/s and also $\varepsilon_0=8.85x10^{-12}$ F/m

$$E=\frac{7.75(P)^{1/2}}{d} \tag{3}$$

SAR value of per unit mass is calculated with Eq. 4:

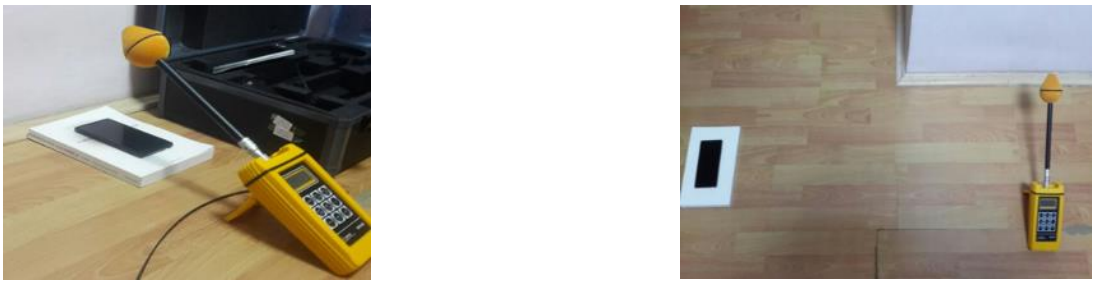
$$SAR=(\sigma+\omega\varepsilon_0\varepsilon_r)\frac{E^2}{\rho} \tag{4}$$

In Eq. 4, σ represents electric conductivity of tissue (S/m), relative permittivity is denotes as ε_r. ω and ρ are angular frequency and tissue density respectively.

B. Measurement of Electromagnetic Radiation

Narda EMR-300 device was used in the study. There is also metre rule, timer and cellular phone in measurement environment. The electric field probe operating in 100 kHz-3GHz frequency band was preferred and measurements were made in a 6-minute time period. Using this measuring instrument via computer software, measurements were recorded on computer every 0.4 seconds and 6 minutes. The mean value of measurement data was calculated. Measurements will be made in the bedroom while staying in bedroom with standby mode cellular phone is intended to investigate radiation that is intended to be placed under pillow at a distance of 17 cm to put phone near to a bed at 1m distance measurements were performed as shown in Fig. 3. During 6-minute measurement period, two different cases were investigated. Finally, measurement was repeated while cellular phone was changed off in order to make comparisons. In order to minimize radiation that may occur outside cellular phone, measurements were started at 05.00 hrs. The WIFI module on cellular phone is turned off during measurement. 3G mobile data was only active. The Bluetooth connection is turned off. The cellular phone used in measurement was selected as Turkcell T50 for measurement. The sim card used as Vodafone. In addition, distance from base station is shown in Fig. 4.

Fig. 2 Narda EMR-300



(a) (b)

Fig. 3 Measurement in a) 17 cm and (b) 1 m range

Fig. 4 Map for distance from base station to measurement location

III. Results And Discussion

The measurements were performed in two different positions and in three different conditions. The measurement data obtained are shown in Table 1. In data analysis, when measurement distance changes from 17 cm to 1m, radiation value decreases. In case where cellular phone receives SMS, there is a slight increase in radiation compared to idle state. It is seen that value obtained in measurement where cellular phone is turn off is less than the smallest measured value obtained in idle state at a distance of 1m. Although cellular phone is turn off, it is normal to have a measurement value of 0,143 V / m. Because sources of electromagnetic radiation operating in the 100 kHz - 3 GHz band are outdoors.

When measurement data is generally evaluated, cellular phone is turned off (0.143 V / m) and minimum radiation at a distance of 1 m (0.15 V / m) is compared [(0.155-0.143) / 0.143] * 100% = 8.4% increase. The rapid increase is directly related to phone's data traffic and will increase level of radiation to be exposed to data traffic that will occur, such as SMS, e-mail and WhatsApp message. In this context, it would be a good choice for cellular phone to be completely shut down or switched to airplane mode in order to avoid exposure to radiation.

Table 1. Average measurement values obtained in different situations and locations

6 min Av. Measurement of Electric Field in V/m	**STANDBY**		**1 SMS**		**TURN OFF**
	17 cm	1 m	17 cm	1 m	
	0,178	0,155	0,223	0,219	0,143

Table 2 shows the limit values for uncontrolled exposure for GSM900 and DCS1800 systems in general public areas. [9].

Table 2. International limit values of uncontrolled exposure

Limits		**For 900 MHz**	**For 1800 MHz**
		ICNIRP	ICNIRP
	Electric Field Strength	41,25 V/m	58,33 V/m

The given limit values are for average values to be obtained as a result of the six-minute measurement. Using these expression in Turkey 900 MHz and limit values must be

observed exposure to uncontrolled area at 1800 MHz as in Table 3.

Table 3. The limit values must be adhered to uncontrolled exposure at 900MHz and 1800MHz in Turkey

	For 900 MHz	**For 1800 MHz**
	Total exposure value	Total exposure value
Electric Field Strength	29 V/m	41 V/m

In Table 2 and Table 3, measurement data was found to be below limit values at uncontrolled area in Turkey.

IV. CONCLUSION

In many countries, it has evaluated EMR values of many cellular phone models in order to avoid non-ionizing radiation.

In this study, EMR exposure intensity of cellular phone at different modes is analysed. The results show that EMR levels in standby, active and turn off modes depend on many factors. They also show that higher EMR intensity is recorded when receiver is allowed to receive calls during active modes compared to the turned off position. In addition, EMR levels at 900 MHz and 1800 MHz frequencies are well below from limit values.

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