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Measurement and Assessment of Long Term Electric Field Strength in Different Locations

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Abstract: As a result of technological developments there has been a substantial growth in the use of mobile communication services and number of base stations over the last few years. Increasing demand for communicating from any place pushes cellular system operators to install more base stations. With the increase in the number of base stations, electric field strengths have also increased. Thus, accurate measurement and assessment of electric field strength (E) levels caused by base stations accordingly are very crucial to take precautions for human health. For this reason, Es were measured for 24 hours at five different locations with PMM 8053 E field meter then assessed. It is seen from the measurement results that the maximum E is 7.88 V/m while the maximum of mean E is 1.83 V/m. Even though the measured E levels are below the limits that are determined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Information and Communication Technologies Authority (ICTA) they exceed the lower limits applied by some countries. It can be also concluded from the measurement results that E levels can change significantly within a day depending on the usage density of the base station.

Keywords: Electromagnetic field measurement, Electric field strength, PMM-8053, Base station, ICNIRP.

I. INTRODUCTION

Electromagnetic waves are radiated from many sources, both natural and man-made, that produce background levels of electromagnetic radiation. The numbers of sources that emit electromagnetic waves such as radio and TV transmitters, base stations, power line transmission, transformers, and all electrical and medical devices have also increased accordingly with growing number of users. In the present day, in parallel with the technological developments, especially in wireless systems, the use of electromagnetic waves has been increased that has resulted in an unavoidable increase in electromagnetic exposure levels. Increasing demand for communicating from any place, multimedia usage push cellular system operators to install more base stations as each base station works within a limited geographical region and for limited number of users [1-2].

Because there is a growing number of base stations being placed into crowded places; measuring, evaluating, EM field levels and controlling their compliance with standards/limit values has become more crucial than before. Therefore, many recent studies have focused on measurement and assessment of electric field strength (E) levels [3-9]. Determining especially the change in emitted E levels from base stations depending on usage density at particular times of day has great importance.

Therefore, differently from the existing works, we evaluate the change in E levels within a day, based on 24 hour long-term measurements conducted at five different locations using PMM 8053 EM field strength meter. Finally, detailed analyses of the measurement data were performed.

This paper is organized as follows: first, an overview of existing EM exposure standards and EM measurements are given. In the next section, measurement results and statistical properties of E are presented. Finally, the paper is concluded in the last section.

II. ELECTRIC FIELD STRENGTH MEASUREMENTS

The wireless systems are indispensable part of our daily lives today and they operate at frequencies below 300GHz, which is within the non-ionizing spectrum that does not carry enough energy to remove an electron from an atom [10].

However the potential health effects of EMR that is emitted by them is still the subject of public debate. There are a number of organizations that investigate potential health effects of non-ionising radiation and offer international standards on exposure limits, such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Institute of Electrical and Electronics Engineering (IEEE). Each country has its own determined limits. Most of these limits are recommended by an international commission ICNIRP, which is recognized by World Health Organization (WHO), and based on the assumption of 24 hour exposure [11].

In Turkey, the regulations on exposure limits for EM fields [12] are released by Information and Communication Technologies Authority of Turkey (ICTA), and the limits are determined on the basis of ICNIRP reference levels. The limits of E are shown in

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Table I based on ICNIRP [11] and ICTA [12] guidelines on exposure limits, and their change as a function of frequency are given in Fig. 1. As seen from Table I. and Fig. 1. the limit values of E in Turkey at 900MHz, 1800MHz are 30.9 V/m, 43.69 V/m respectively and 45.75 V/m for both 2100MHz and 2.45 MHz (Wi-Fi).

TABLE I REFERENCE LEVELS FOR GENERAL PUBLIC EXPOSURE TO TIME-VARYING ELECTRIC FIELDS FOR ICNIRP AND ICTA

Frequency range (f, MHz)	**E (V/m)**	
	ICNIRP	**ICTA**
0,010 – 0,15	87	65,25
0,15 – 1	87	65,25
1 – 10	$87/f^{1/2}$	$65{,}25/f^{1/2}$
10 – 400	28	21
400 – 2000	$1{,}375f^{1/2}$	$1{,}03f^{1/2}$
2000 - 60000	61	45,75

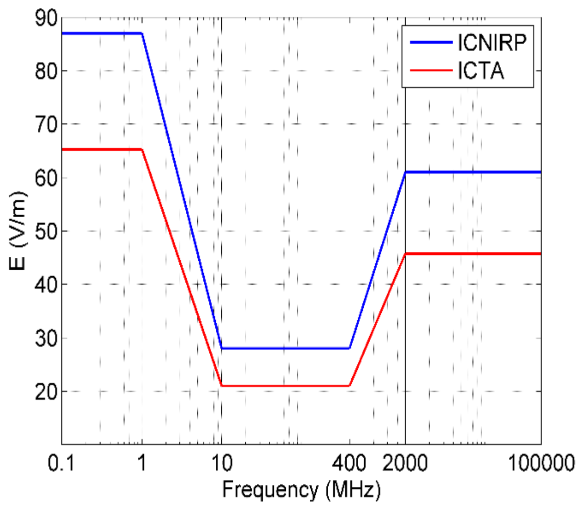

Fig. 1. The change of E limits as a function of frequency

In this study, in order to evaluate the change in E levels within a day; E measurements were conducted during 24 hours a day with a four seconds sampling period [6] at five different locations using PMM 8053 portable EM field strength meter with an EP-330 isotropic E-field probe [13].

Total Es in the band between 100 kHz - 3GHz (including FM, TV, GSM, UMTS and WLAN services) can be measured with PMM–8053. The measurements were performed between October 2015 and March 2016 and named as M1, M2, M3, M4 and M5. M1 shows the first measurement location that is on University Campus, while M2, M3, M4 and M5 represent the measurement locations on a hospital, at a pharmacy, an apartment, and a shopping mall respectively. The measurement locations are displayed on Fig. 2.

Fig. 2. Pictures of E measurements at different locations using PMM–8053 EM field meter

III.MEASUREMENT RESULTS

The Es recorded through the 24 hours long-term measurements at five different locations are given in Fig. 3. As seen from the results of M1 that the significant increase occurs in E levels during midday when the students are on campus and the base stations are used heavily. The E value decreased after 16:00 as students started to leave campus. Since constant visitors and patients are in service throughout the entire day; there are no sudden fluctuations in E for M2 except between the

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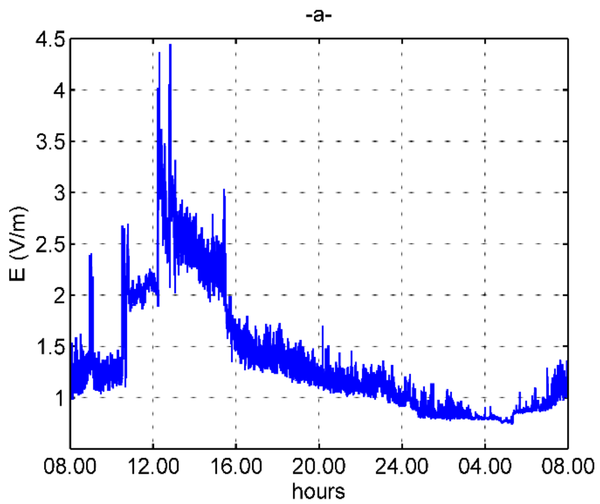
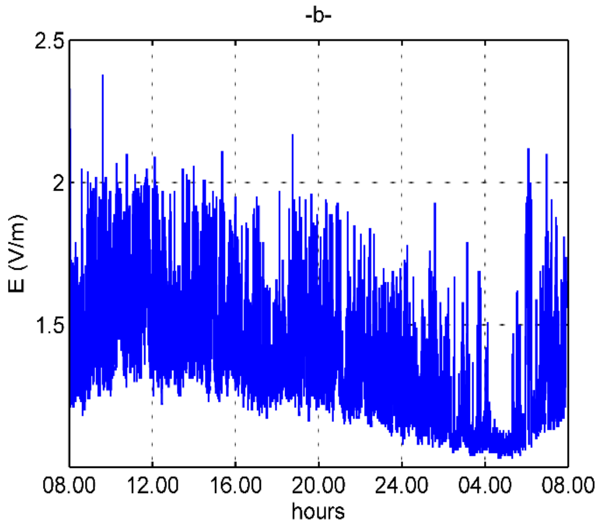
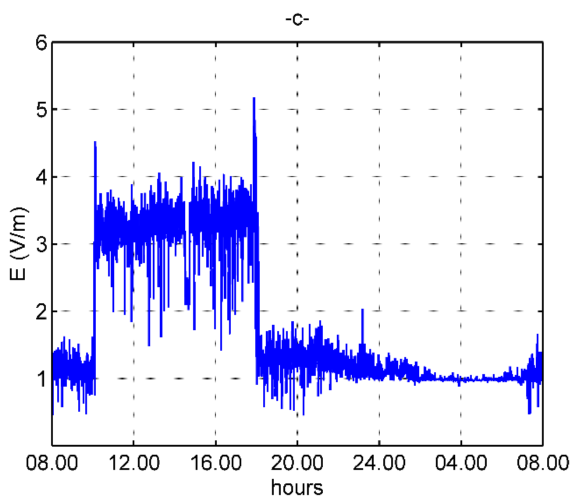
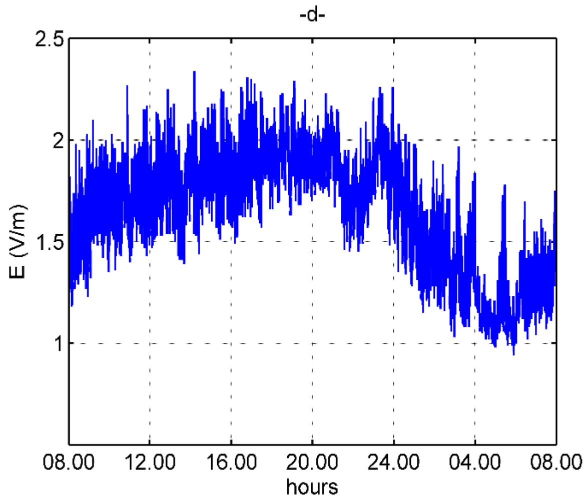
hours 04.00-06.00. Because M3 is conducted at a pharmacy; it's opening and closing hours directly affect the measured E levels. The increase and the decrease in E levels occur accordingly to the working hours. For the case of M4, the E level dropped after 24:00 because usage of the base station was lower.









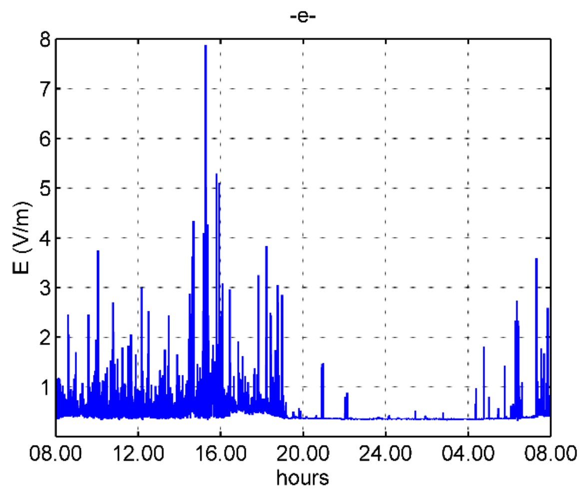


Fig. 3. Measured E levels for a 24 hours period of a) M1, b) M2, c) M3, d) M4 and e) M5

The change in E levels of M5 shows that a significant change occurs between 10.00-22:00 when the shopping mall is open, the substantial decrease in E starts after 22:00 with the closing. It can be concluded from evaluation of the measurement results that the measured E levels can vary with time depending on base station usage density and the number of active users.

The statistical properties of measurements are given in Table II.

TABLE II STATISTICAL PROPERTIES OF MEASUREMENT RESULTS

Measurement Location	E (V/m)		
	Maximum	Mean	Standard Deviation
M1	4.45	1.36	0.57
M2	2.38	1.38	0.23
M3	5.18	1.83	1.04
M4	2.34	1.65	0.29
M5	7.88	0.55	0.49

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As seen from the Table that the maximum E is 7.88 V/m recorded in M5, while the maximum of mean (averaged over a 24 hours) is reached in M3 at 1.83 V/m. The maximum standard deviation is also calculated as 1.04 V/m for M3.

The empirical cumulative distribution functions (CDF) of the measured E levels is shown in Fig.4. It can be concluded from Fig. 4. that for M1, 90% of recorded E levels are below 0.82 V/m, while for M3 below 3.41 V/m.

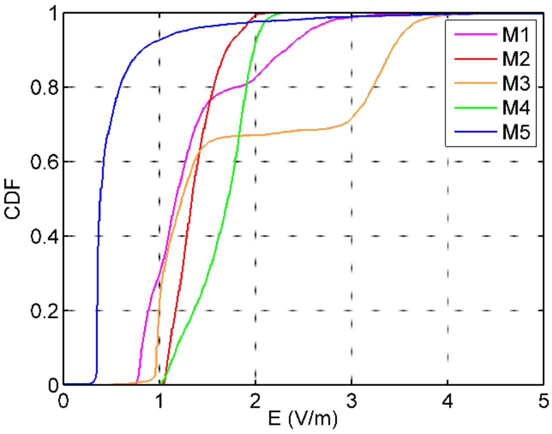

Fig. 4. CDFs of measurement results

IV. CONCLUSION

In this study the changes in E levels within a day are evaluated based on 24 hours long-term measurements conducted at five different locations. It is seen from the results that measured E levels vary with the measurement location and time. As a result of base station usage density; the substantial increase is observed in E levels that recorded especially in day measurements. Overall assessment of measurement results shows that the maximum E value is 7.88 V/m. Although this value is below the limit suggested by ICTA, it is above for countries like Switzerland and Italy where the lower limits are applied than those suggested by ICNIRP.

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