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# Determination of the Annual Change in Electromagnetic Field Levels in Unye, Ordu/Turkey

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**Abstract**: Substantial growth in the use of wireless communication services over the last few years has led to an increase in the number of base stations. Consequently, exposed Electromagnetic Radiation (EMR) levels has risen. Therefore, monitoring of exposed EMR levels emitted by base stations have become more crucial than before for human health. For this reason, in this study EMR measurements were conducted in the years of 2015, 2016 and 2017 in Unye which is one of the most populated districts of Ordu/Turkey. The total electric field strength (E) in the band between 100 kHz – 3 GHz was measured using PMM-8053 EMR meter, and the maximum E ($E_{max}$) and the average E ($E_{avg}$) were recorded at 47 different locations. According the total 141 measurement results, the maximum $E_{max}$ is 6.05 V/m, while the maximum $E_{avg}$ is 2.40 V/m that both recorded in 2017. Furthermore, only 2% of all measurement results are above 2 V/m of each years' measurement. Based on the measurement results annual percentage change in $E_{avg}$ levels are 15.2% and 21.5% from 2015 to 2016, and from 2016 to 2017 respectively. Since E levels in the environment have continuous tendency to increase, accurate monitoring and evaluation of E levels is very crucial to keep exposed EMR levels below the limits.

**Keywords**: Electromagnetic radiation, Electric field strength (E), Base station, ICNIRP, PMM-8053.

## I. INTRODUCTION

The rapid development and increased use of wireless communication technologies led to a substantial change in the unavoidable exposed Electromagnetic Radiation (EMR) levels. In cellular systems, a form of the wireless communication systems, users communicate each other over base stations. Increasing demand for mobility and multimedia has resulted in more base station installation as each base station works within a limited geographical region and for limited number of users [1-5]. Meeting this demand will translate into greater, long term human exposure to EMR. Although base stations operate at frequencies below 300GHz, which is within the non-ionizing spectrum, potential risks from this technology can lead to concern within the public [6]. Therefore, several measurement studies have been conducted characterizing EMR exposure levels in different environments [7-14]. Although the effects of EMR on human health cannot be clearly specified, international standards and limit values have been determined to stay within safe limits. The most widely accepted limit values are set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [15], which is recognized by the World Health Organization (WHO). Turkey applies the limits which are 75% of ICNIRP reference levels, as endorsed by Turkey's Information and Communication Technologies Authority (ICTA) [16]. The limits of electric field strength (E) are shown in Fig. 1, based on ICNIRP and ICTA guidelines on exposure limits. As usage density of wireless communication systems are still rising, it is necessary to update existing studies and to carry out new ones. By doing this, monitoring time trends of EMR exposure over years and comparing exposure levels between different time intervals are become possible. For this reason, this study aims to determine the annual change in EMR levels in Unye which is the most populated (120000) district of Ordu. In order to reach this goal EMR measurements conducted at differently populated parts of Unye using PMM-8053 EMR meter [17]. The first measurement was performed at 47 different location in 2015, the following measurements were conducted at the same locations in 2016 and 2017.

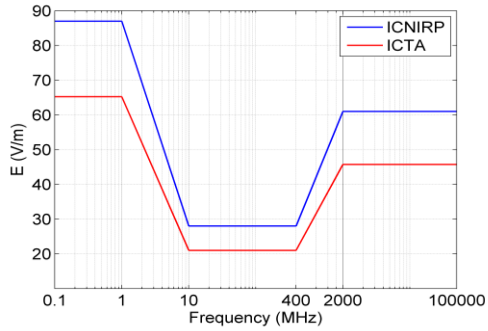


Fig. 1 The ICNIRP and ICTA limits according to carrier frequency

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## II. ELECTRIC FIELD STRENGTH MEASUREMENTS

In this study, long term EMR measurements were conducted in Unye district of Ordu at 47 different locations in 2015, and the measurements were repeated at the same locations in 2016 and 2017. Then the necessary evaluations were made, and annual change in E levels was determined. The rough measurement locations are shown in Fig. 2 with blue circles. The measurements were performed considering cellular systems usage density, line of sight, and distance from a base station.

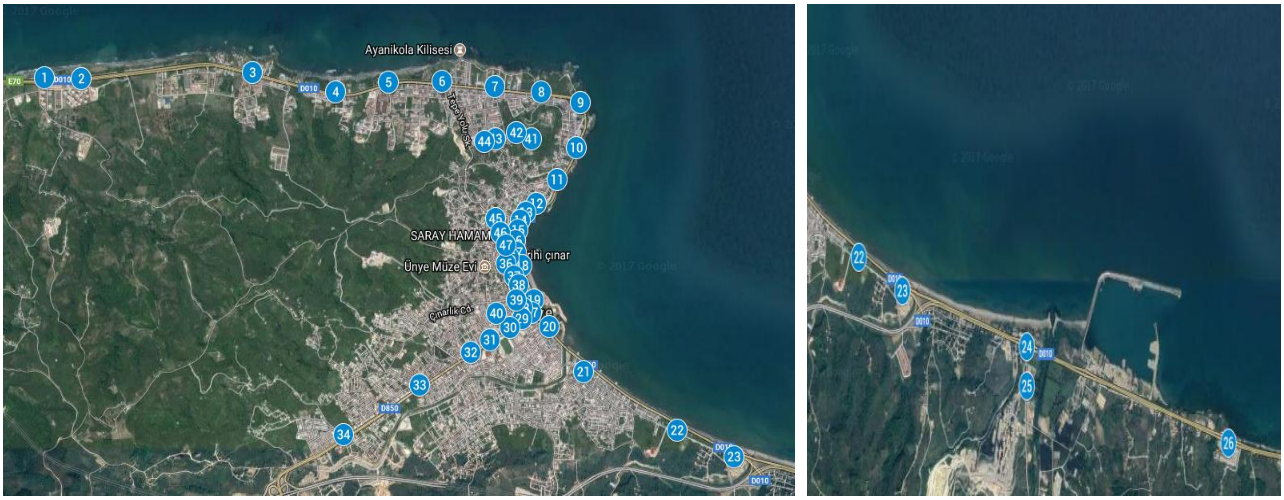


Fig. 2 Measurement locations

The EMR measurements were conducted using PMM-8053. The total E in the band between 100kHz - 3GHz can be measured using PMM-8053 with EP-330 isotropic electric field probe [17]. Sensor measurement range of a PMM-8053 is 0.3 V/m - 300 V/m. The maximum, the minimum and spatial and temporal averages of E (V/m), magnetic field strength (A/m) and power flux density (W/m$^2$), can be measured. In this study, the maximum E ($E_{max}$) and the average E ($E_{avg}$) were recorded at each measurement location. According to international standards and ordinances released by ICNIRP and ICTA duration of each measurement was six minutes. The example images of the measurement process are shown in Fig. 3.


Fig. 3 EMR measurements with PMM-8053

## III. MEASUREMENT RESULTS

Recorded E values at 47 different locations in three consecutive years are shown in Fig. 4.a and b for $E_{max}$ and Eavg respectively. In figures M1 represents the measurement results of the year of 2015, while M2 and M3 shows results of 2016 and 2017.

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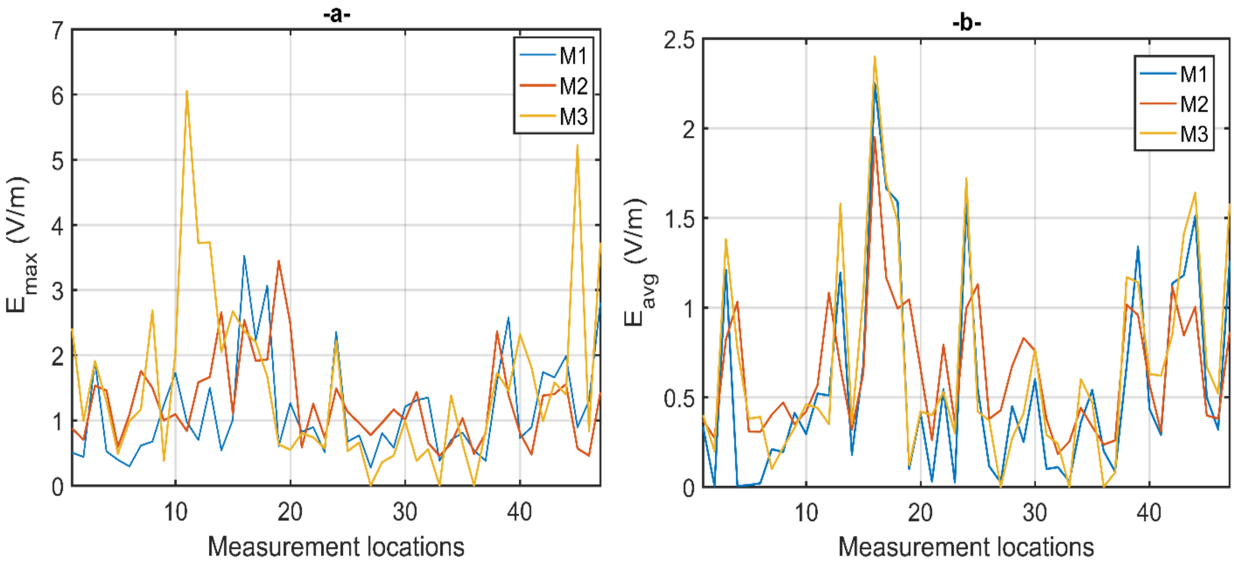


Fig. 4. a) $E_{max}$ b) $E_{avg}$ versus measurement locations

As seen from the figures, E levels change with measurement location significantly. Reasons of this drastic and sudden changes may be distances from base stations, base stations' output powers, and number of active users. In the first measurement (M1); the maximum recorded $E_{max}$ is 3.53 V/m at location 16 (L16), while the maximum $E_{avg}$ is 2.25 V/m at L16. Statistical properties of all measurement data are summarized in Table I.

TABLE I STATISTICAL PROPERTIES OF MEASUREMENT RESULTS

| Measurement | $E_{max}$ (V/m) | | | $E_{avg}$ (V/m) | | |
|---|---|---|---|---|---|---|
| | **Max** | **Mean** | **Std** | **Max** | **Mean** | **Std** |
| M1 | 3.53 | 1.16 | 0.78 | 2.25 | 0.55 | 0.56 |
| M2 | 3.45 | 1.25 | 0.65 | 1.95 | 0.64 | 0.36 |
| M3 | 6.05 | 1.54 | 1.30 | 2.40 | 0.67 | 0.56 |

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In order to determine the distribution of $E_{avg}$s that recorded in M1, M2, M3; pie charts are plotted and illustrated in Fig. 5.a, b, c respectively. As seen in the figure, 57% of recorded $E_{avg}$s are between 0-0.5 V/m for M1, while 49% and 55% of $E_{avg}$s change within the range 0-0.5 V/m for M2 and M3 respectively.

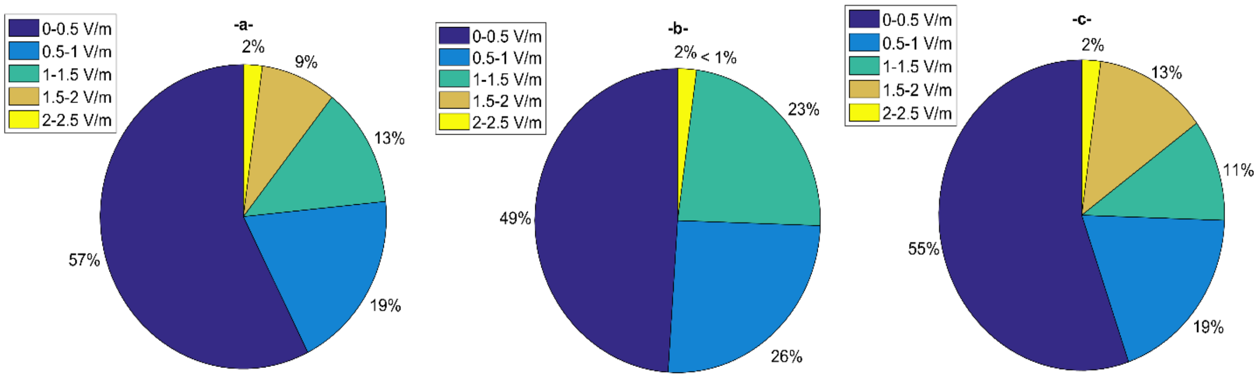


Fig. 5. Pie chart of $E_{avg}$ for a) M1 b) M2 c) M3

In order to better observe the annual change in E levels, the measured $E_{avg}$s were transferred onto scaled color map using MapInfo and given in Fig. 6.a, b, c for M1, M2, and M3 respectively. The use of these maps help to determine the changes virtually, and compare the E values of each measurement location easily.

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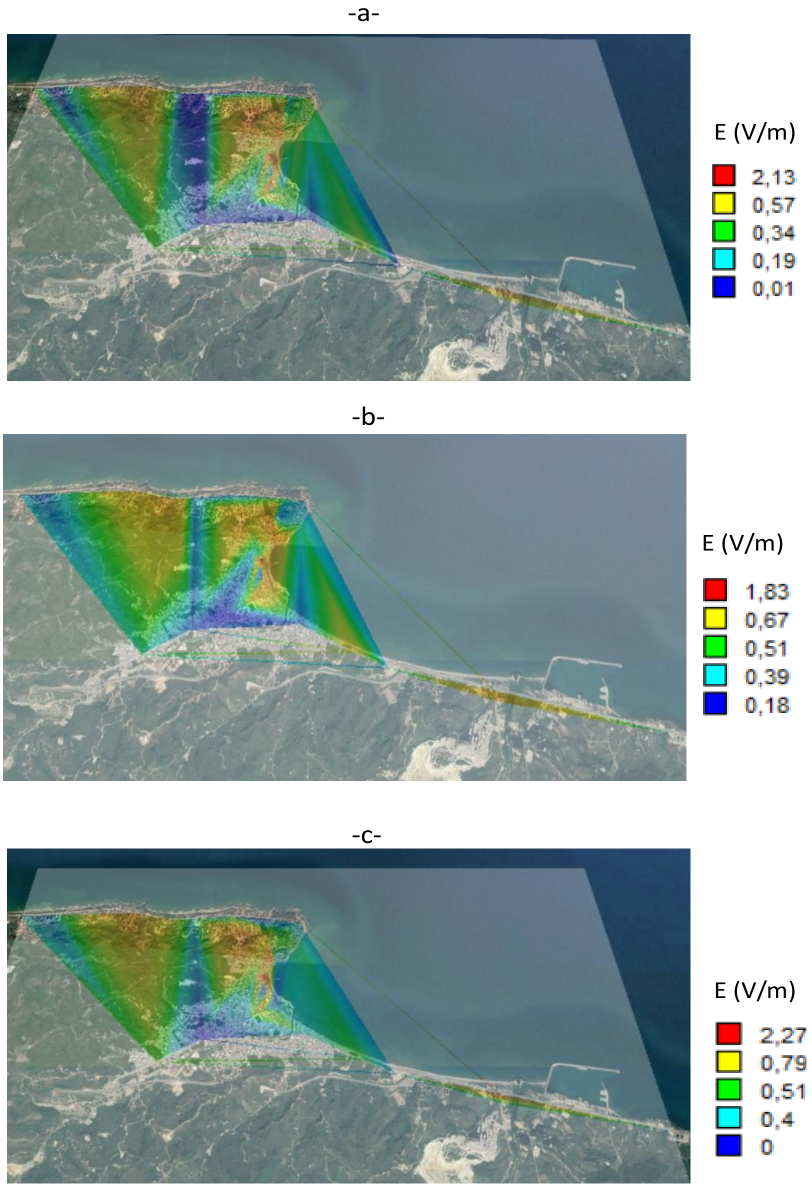


Fig. 5. Color maps of $E_{avg}$s for a) M1, b) M2, c)M3

## IV. CONCLUSION

In this study, in order to determine the annual change in E levels, short term E measurements were performed at 47 different locations in Unye district of Ordu in the years of 2015, 2016 and 2017. It is seen from the measurement results that E levels may vary with the measurement location and time, and the maximum recorded $E_{max}$ is 6.05 V/m while the maximum $E_{avg}$ is 2.40 V/m both obtained in M3. The results also demonstrate that the mean of $E_{avg}$ increased by 15.2% from M1 to M2, while 21.5% from M1 to M3. It can be concluded from the measurement results that, continuous monitoring of E levels is very crucial for human health since exposed E levels in the environment tend to increase.

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