



Mapping of electric field intensity distribution in the 27 MHz - 3000 MHz frequency range in Diyarbakir city center

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ABSTRACT

It is evident that the rapid development in science and technology has enabled various electronic devices and communication systems. However, there are also undesired effects of those devices on human health. One of those effects is the electromagnetic fields that exceeds the limits. Therefore, the electromagnetic fields emitted by the devices should not exceed a certain level. In that respect, different institutions around the world have determined the certain limits. One of the most important of these organizations in the world is the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Similar to the other existing organizations, the Information and Communication Technologies Authority (BTK) is the responsible authority in Turkey. In this study, electric field intensity values were measured using the drive test method with the Selective Radiation Meter (SRM-3006) device on the main streets in Diyarbakir City Center. Obtained measurement values were shown on dot thematic maps, two-dimensional maps and three-dimensional maps. As a result, locations with the highest electric field intensity were determined by these maps. In addition, the obtained results were compared with the limit values determined by ICNIRP and BTK and it was seen that the measured electric field intensity values did not exceed the exposure limits.

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Introduction

Mobile devices have become an indispensable part of our lives due to the communication age we are living in. As a result, the communication network and infrastructure in cities has gradually expanded especially with the development of 2nd, 3rd and 4th generation communication systems. Electromagnetic waves are the most important component of mobile communication systems that surround the living spaces. Although those waves are not ionizing, it may pose a certain threat on human health if it exceeds certain values. Therefore, certain limits are determined by organizations such as ICNIRP [1] and BTK [2]. In Turkey, many studies have been performed in order to examine the relevance of the electric field intensity with the limit values in the city center or residential areas.

In the study conducted by Cansız [3] in 2010, NBM 520 wide band electromagnetic field meter device belonging to Narda company for use in high frequency electromagnetic field measurement and EHP-50C electric and magnetic field meter device belonging to Narda company for use in low frequency electromagnetic field measurement were used to carry out mobile and manual measurements in Diyarbakir city center. The data obtained as a result of the study were shown on the digital satellite map and then compared with the reference limits accepted by ICNIRP.

In 2015, a study was conducted [4] by measurements with the drive test method using BTK approved devices in order to create electromagnetic field maps in the 100 KHz – 3 GHz frequency range of Balikesir city center and Balikesir University Cagis Campus. Then, the measured values were compared with national and international electromagnetic field (EMF) exposure limit values. As a result, it was determined that the limit values were not exceeded.

In another work, Cansız [5] measured RF EMF exposure levels of FM, TV3, TV4-5, GSM 900, GSM 1800 and UMTS bands on the main roads in Diyarbakir City Center with the drive test method with SRM 3006 and a three-axis antenna in 2016. Using the data obtained, electromagnetic pollution level was mapped in Diyarbakir city center. In addition, it has been determined that the obtained electric field intensity values are below the limit values announced by national and international organizations.

The examples can be expanded further. For example, unlike the previously listed studies 60 measurements at 46 different points in the city center of Sinop for 30 days with the Extech 480836 device was also carried out, which covers the frequency range of 50-3500 Mhz and performs broadband measurement [6]. The measurement points are shown on the map and the electromagnetic pollution map is revealed according to the obtained values. It has been

determined that the obtained values are not above the limit values reported by BTK.

In another study [7], carried out in 2019, electric field intensity measurements were performed at 19 different points in Marmara University Başbüyük Campus by using SRM 3006 device to analyze electromagnetic field pollution in different weather conditions. It has been determined that the data obtained in the measurements are below the limit values announced by national and international organizations.

In the study conducted by Memişoğlu [8] in 2019, electromagnetic field intensity values in kindergartens in the city center of Rize were determined by using the SRM 3006 device and a three-axis antenna. The results of the measurements made at different times of the day in 22 different kindergartens were presented with tables and graphs and compared with the limit values announced by the BTK. As a result of the comparison, it was seen that the determined limit values were not exceeded. In addition, recommendations are also included in the study to avoid exposure to electromagnetic field pollution.

In 2020, measurements at 11 different points at 4 different times in the center of Beşpınar town of Demirözü district of Bayburt province and around the town was also performed by using the SRM-3006 device [9]. Although sometimes high values are found in the measurements, it has been reported that the limit values determined by national and international institutions are not exceeded.

In this study, the electric field intensity values at 27 MHz – 3000 MHz frequency range and some important bands that between this frequency range such as FM, TV, LTE800, 2G, LTE1800, 3G, LTE2100, WLAN, LTE2600 were measured using the drive test method on the route determined in Diyarbakır city center. Measurements were made using the Narda SRM 3006 device [10]. These data, which were transferred to the computer environment later, were converted thanks to the Matlab software [11] into txt file format that includes latitude, longitude of measurement points and instantaneous maximum electric field intensity values for use in the Mapinfo program [12]. The txt files uploaded to the MapInfo program were processed and the electric field intensity at 27 MHz – 3000 MHz, FM, TV, LTE 800, 2G, LTE 1800, 3G, LTE 2100, WLAN, LTE 2600 bands on the measurement route in Diyarbakır city center visualized and presented using dot thematic map, 2D and 3D maps. In this way, according to the frequency range, where and what values of the electric field intensity in Diyarbakir were seen.

Material and Methods

Mobile measurements were carried out using the drive test method between 15:30 and 18:30 on 14.04.2021 in the city center of Diyarbakir. Maximum instantaneous electric field intensity values were measured at a total of 797 points by measuring once in 6 seconds while moving at a speed of 40 km per hour with the mobile measurement car on the measurement route. Using the SRM-3006 device and a three-axis antenna, the total electric field in the 27 MHz – 3 GHz frequency range, as well as the electric field values in the FM, TV, LTE 800, 2G, LTE

1800, 3G, LTE 2100, WLAN, LTE 2600 bands, were also measured and recorded separately. The SRM-3006 device, produced by Narda company, is a measuring device for safety analysis and environmental measurements of high-frequency electromagnetic fields in the 9 kHz to 6 GHz frequency range. The SRM-3006 measurement system consists of a single axis or triaxial antenna and the SRM-3006 main unit. In the mobile measurements we made in Diyarbakır city center, an antenna capable of measuring three-axis E-field and measuring in the frequency range of 27 MHz - 3 GHz was used. The SRM-3006 device and triaxial antenna used in mobile measurements are shown in Figure 1.



Figure 1. SRM-3006 device and triaxial antenna.

In order to carry out mobile measurements, the three-axis electric field antenna was mounted on the car thanks to a special vacuum. A 1.5 meter long connecting cable was used to connect the SRM main unit and the triaxial antenna. The mobile measurement setup is shown in Figure 2.



Figure 2. Mobile measurement car.

Results and Discussion

The recorded 797 measurement values were transferred to the computer environment via the Narda 3006 SRM Tools software. The obtained data were tabulated as latitude, longitude and maximum electric field value by using Matlab software and uploaded to the Mapinfo program as a txt file. Using the data uploaded to the MapInfo

program, the route, dot thematic map on the route, 2D maps and 3D maps were created in the city center of Diyarbakir. Figure 3 shows the measurement route in Diyarbakir city center.

The measurement route shown in red in Figure 3 is determined by considering the main roads, the busiest boulevards and streets in the city center of Diyarbakir. Each red dot represents the locations where the measurement is performed. The measured bands with the drive test method in Diyarbakir City Center, the number of measurements made for each band, the frequency ranges of the bands and the measured highest and average values of electric field intensity and standard deviation of the electric field intensity distribution are shown in Table 1.



Figure 3. Routes and points where electric field intensity measurements are made in Diyarbakir city center.

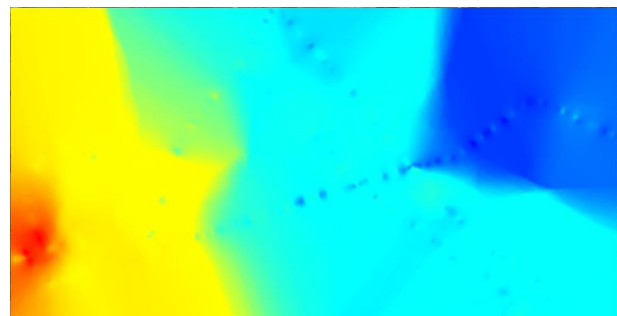
Table 1. Measured EMF bands and frequency ranges in Diyarbakir City Center

Service Name	Number of Measurements	Min. Frq. (MHz)	Max. Frq. (MHz)	Max. E. (V/m)	Avg. E. (V/m)	Standard Deviation
FM	797	88	108	4.648	0.2903	0.6342
TV	797	470	790	1.686	0.2026	0.2626
LTE 800	797	791	821	3.766246	0.5507	0.4952
2G	797	935,1	1820	4.562419	0.7053	0.5997
LTE 1800	797	1820,1	1879,9	3.962747	0.6395	0.5007
3G	797	2110	2160	4.96885	0.8489	0.5552
LTE 2100	797	2160	2170	4.135	0.1848	0.2547
WLAN	797	2400	2483	0.1973	0.1447	0.0151
LTE 2600	797	2620	2670	3.194840	0.3803	0.3352
Total E Field	797	27	3000	6.943	1.7824	1.0084

As seen in Table 1, the highest electric field intensity value among FM, TV, LTE800, 2G, LTE1800, 3G, LTE2100, WLAN, LTE2600 bands was recorded as 4.96885 V/m in the 3G band in the measurements made in Diyarbakir city center. The lowest value among all bands is 0.1973 V/m, which is the highest value of the WLAN band. The highest electric field intensity value in 27 MHz – 3000 MHz was measured as 6.943 V/m. These values were measured at different coordinates on the measurement route. These values and the electric field intensity values in other locations where measurements were made were visually shown in three different ways as dot thematic map, 2D map and 3D map on the Google Map satellite image of Diyarbakir city by using the Mapinfo program. Thus, the electric field intensity distribution of the measured frequency bands can be clearly seen on maps. Figure 4 shows electric field intensity distribution at FM band which covers 88 MHz – 108 MHz frequency range.



a)



b)

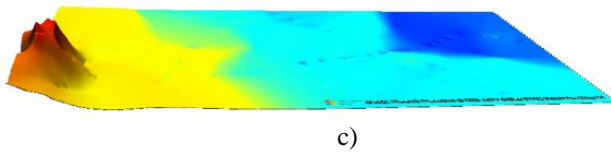


Figure 4. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the FM band in Diyarbakir city center

In the above figures, the locations with the highest electric field intensity in the FM band are shown in red. As the figure demonstrates, the red region is concentrated in a certain region which is caused by the FM receiver/transmitter station on the region named Talaytepe. The electric field intensity in the FM band decreases to a great extent as moving away from the station.

In Figure 5, the electric field intensity distribution measured in the TV frequency band that is between 470 MHz - 790 MHz is shown on the maps.

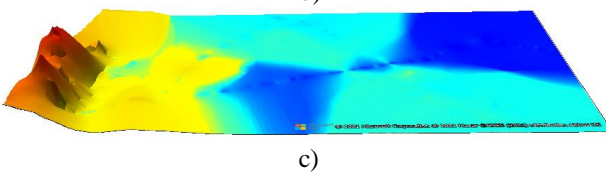
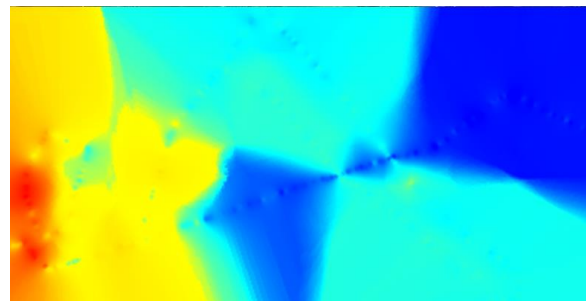


Figure 5. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the TV band in Diyarbakir city center

It is seen that the electric field intensity is concentrated on Talaytepe hill in the TV band as it is in the FM band.

Figure 6 shows the electric field intensity of the LTE800 band which is between 791 MHz – 821 MHz frequency.

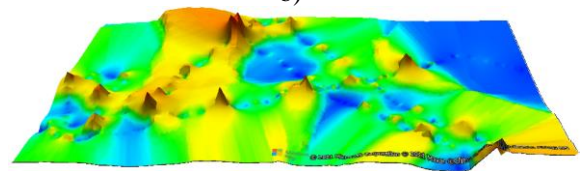
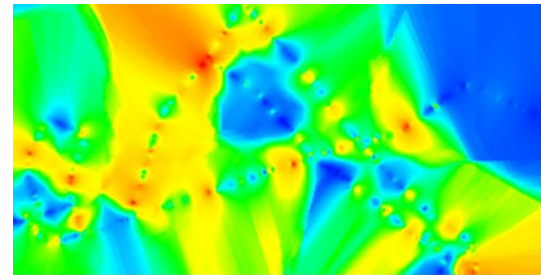
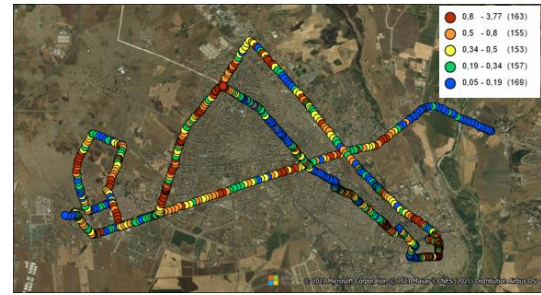
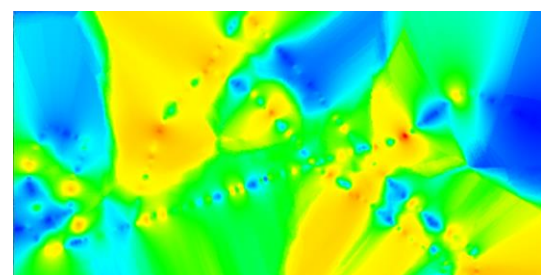
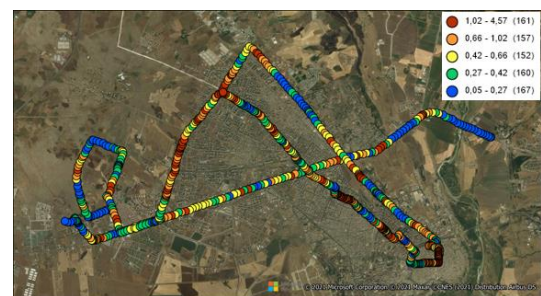


Figure 6. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the LTE800 band in Diyarbakir city center

According to the maps in Figure 6, it is seen that the electric field intensity in the LTE800 band is especially concentrated on Mahabad boulevard, Urfa street and Gazi street in Sur district. This is largely due to the base stations on these streets due to the human population.

Figure 7 shows the electric field intensity of the 2G band which is between 935.1 MHz – 1820 MHz.



b)

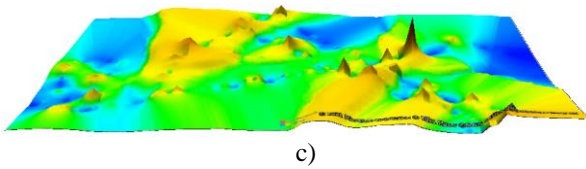


Figure 7. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the 2G band in Diyarbakir city center

According to Figure 7, the electric field intensity in the 2G band is especially concentrated in Seyrantepe district, Turgut Özal boulevard, Mahabad boulevard and Gazi street.

The maps that show electric field intensity distribution of the LTE1800 band which is between 1820,1 MHz – 1879,9 MHz frequency range are presented in Figure 8.

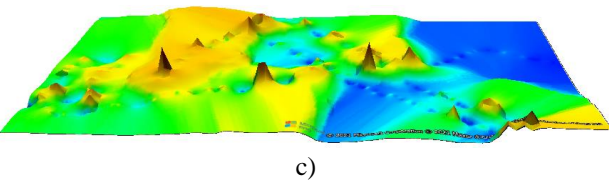
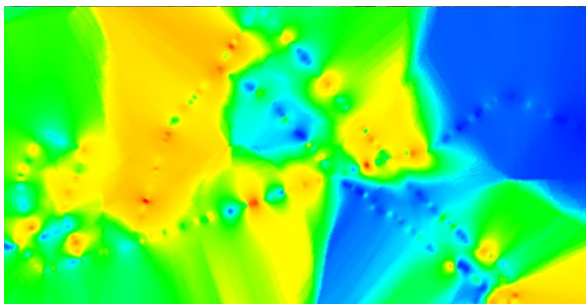


Figure 8. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the LTE1800 band in Diyarbakir city center

According to Figure 8, the electric field intensity in the LTE1800 band is especially concentrated on Mahabad boulevard, Urfa street, Seyrantepe district and Gazi street.

Figure 9 shows electric field intensity distribution maps of the 3G band that is between 2110 MHz – 2160 MHz frequency range.

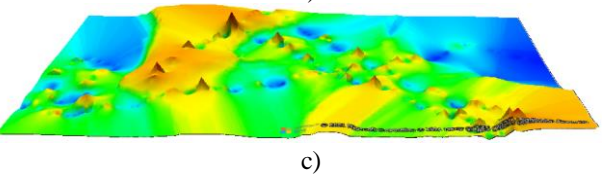
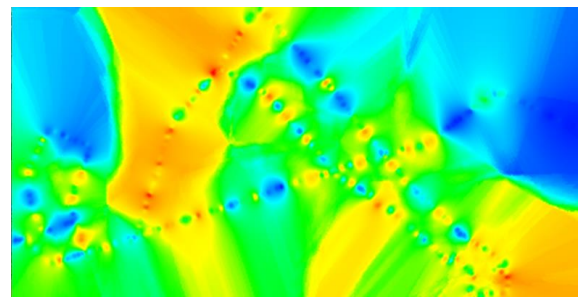
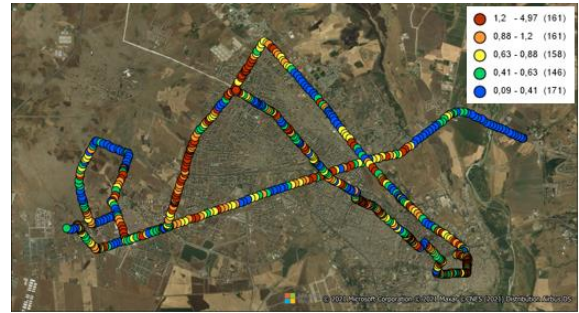
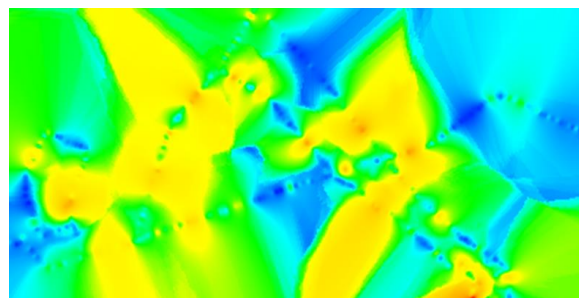
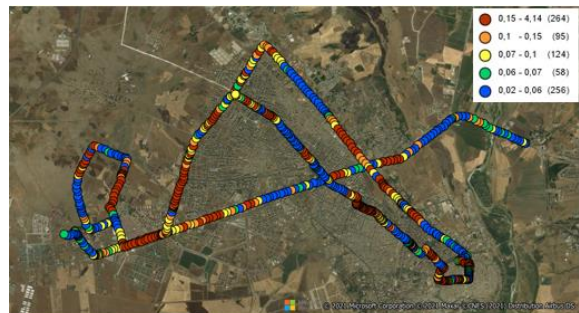


Figure 9. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the 3G band in Diyarbakir city center

As seen in Figure 9, the electric field intensity in the 3G band is especially concentrated in Mahabad boulevard and Gazi street.

Electric field intensity distribution maps of the LTE2100 band covering the 2160 MHz – 2170 MHz frequency range are as shown in Figure 10.



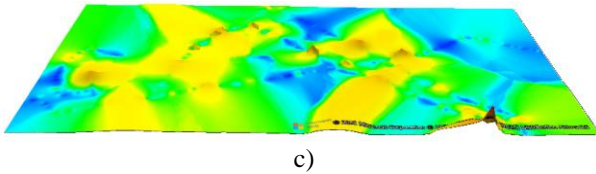
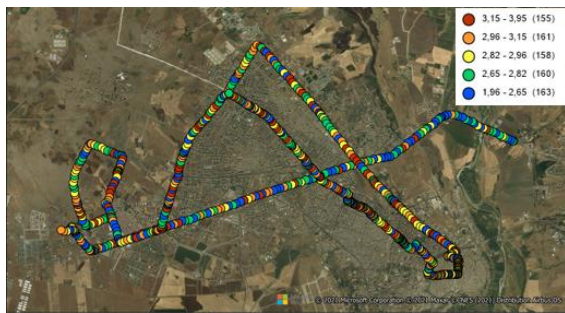


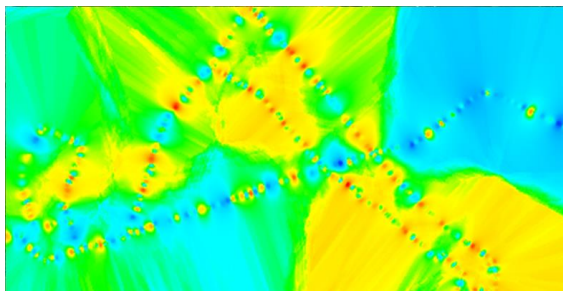
Figure 10. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the LTE2100 band in Diyarbakir city center

As seen in Figure 10, the electric field intensity in the LTE2100 band has a relatively uniform distribution. Measured peak value was measured as 3.194840 V/m in Sur district. Standard deviation of the distribution was calculated as 0.2547.

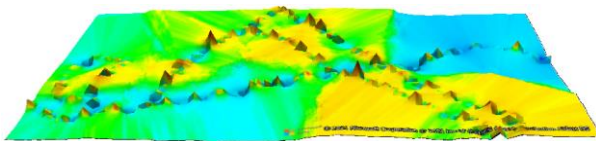
Electric field intensity distribution maps of the WLAN band covering the 2400 MHz – 2483 MHz frequency range are shown in Figure 11.



a)



b)

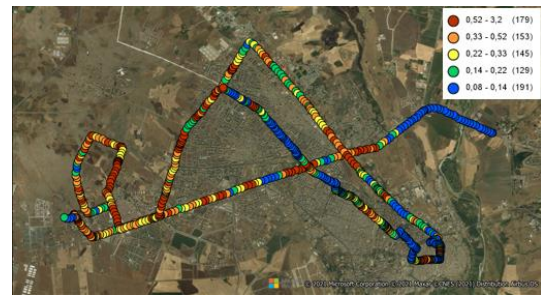


c)

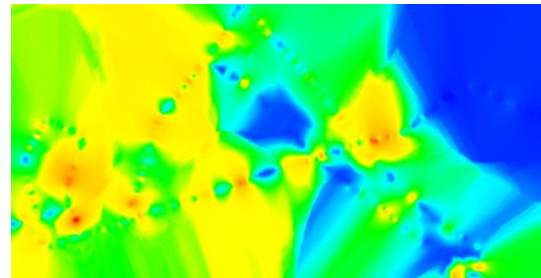
Figure 11. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the WLAN band in Diyarbakir city center

WLAN is a computer network that enables one or more devices to be connected to each other by wireless communication. Since it works with less power than mobile communication systems, the electric field intensity it causes is lower. As seen in Figure 11, the electric field intensity in the WLAN band shows a more homogeneous distribution on the measurement route. Therefore, as presented in Table 1, the maximum electric field intensity is lowest in WLAN and the standard deviation is quite low, at 0.0151.

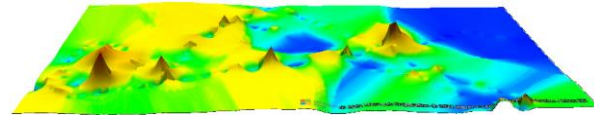
Electric field intensity distribution maps of the LTE2600 band that is between 2620 MHz – 2670 MHz frequency range are shown in Figure 12.



a)



b)



c)

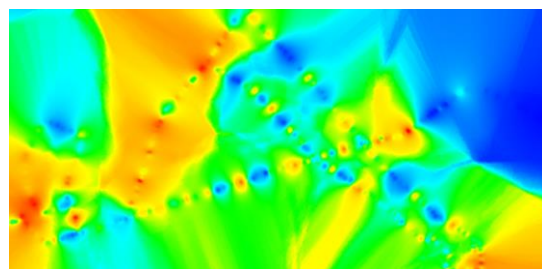
Figure 12. Dot thematic map (a), 2D map (b), 3D map (c) of electric field intensity in the LTE2600 band in Diyarbakir city center

As seen in Figure 12, the electric field intensity in the LTE2600 band is especially concentrated in Urfa street and Mahabad boulevard. Measured maximum electric field intensity is 3.194840 V/m and standard deviation of the distribution is 0.3352.

Electric field intensity distribution maps of the Total band covering the 27 MHz – 3000 MHz frequency range are shown in Figure 13.



a)



b)

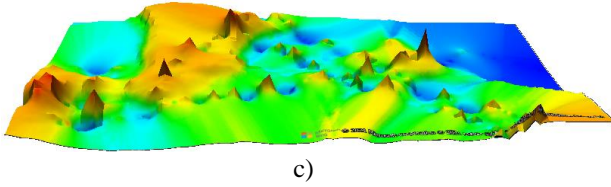


Figure 13. Dot thematic map (a), 2D map (b), 3D map (c) of the total electric field intensity in Diyarbakir city center

As seen in Figure 13, the electric field intensity in the 27 MHz – 3000 MHz frequency range is concentrated in Talaytepe, Mahabad boulevard and Gazi street. In addition, there are concentrated points on Urfa Street and Seyrantepe district. When compared with other bands, the standard deviation is the highest with a value of 1.0084. The reason of this is that while the electric field intensity is higher in certain places, the electric field intensity is lower in other places. Especially in the 2D map in Figure 13b and the 3D map in Figure 13c, the regions where the electric field intensity is highly concentrated are clearly seen.

Conclusion

This paper investigates the electric field intensity values that have been measured by the drive test method using the SRM-3006 device in the city center of Diyarbakir. Mobile measurements were carried out at 797 points on the determined route. The measurements were carried out on the busy streets of the city center and during peak hours of human activity. Electric field intensity values in FM, TV, LTE 800, 2G, LTE 1800, 3G, LTE 2100, WLAN, LTE 2600 bands, as well as the total electric field intensity in the entire 27 MHz – 3 GHz frequency range, were separately measured with a mobile measuring car. The highest value of the total electric field intensity was measured as 6.943 V/m, and it was seen that this value did not exceed the limit values determined by ICNIRP and BTK. In addition, using the data obtained as a result of mobile measurements, dot thematic maps, 2D maps and 3D maps were created and the electric field intensity distribution was presented visually.

Although the highest electric field intensity values in the measurements were below the limit values of ICNIRP and BTK, these studies should be carried out periodically by including new settlements to be established in the measurement route and it should be checked whether the limit values are exceeded.

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