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Evaluation of the Exposure of 4.5G Mobile Phone Base Stations in Different Band Radio Frequencies in Urban Center and Rural Areas in Turkey.

Türkiye'de 4.5G Cep Telefonu Baz İstasyonlarının Kent Merkezinde ve Kırsal Alanda Yaşayan İnsanların Farklı Band Radyo Frekanslarına Maruz Kalmasının Değerlendirilmesi

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ABSTRACT

Mobile phone base stations (MPBS) are electronic communication equipment, the number of which is rapidly increasing with the increasing need for mobile data use with developing technology. Since the middle of the 21st century, the effects of Radio Frequency Electromagnetic Fields (RF-EMF) emitted from base stations on human health have begun to be investigated. Although some of these studies have explained the harmful effects of RF-EMF on human health, others have stated that its effects on human health are limited and therefore contradictory results have emerged. RF-EMFs can have effects by transferring energy to human tissues, increasing temperature and changing the way cell membranes work. These effects may vary inversely with the proximity of MPBSs to residential areas and their safety distances. In this regard, rules such as location at least 300 m away from places with high population density (schools, hospitals, shopping malls, etc.) and at least 40 m above the ground are required. In this study, RF-EMF values of base stations installed both in Rize city center and rural areas in Turkey in different 4.5G frequency bands (GSM 900 DL- 1800 DL-2100 DL) were analyzed by real-time selective area analyzer (NARDA- It is measured using SRM 3006). The safety distances in the production/label values of these base stations, mathematically calculated EMF and measurement values were compared for different distances. Base station production/label and real-time measurement values of RF-EMF values emitted by MPBSs in urban centers and rural areas are determined and their effects on human health are evaluated.

Keywords: Electromagnetic Field, Human Health, Mobil Phone Base Stations, Radio Frequency, Rural Areas, Urban Centers,

ÖZ

Cep telefonu baz istasyonları (MPBS), gelişen teknolojiyle mobil veri kullanımına olan ihtiyacın artmasıyla sayıları hızla artan elektronik haberleşme ekipmanlarıdır. 21. yüzyılın ortalarından itibaren baz istasyonlarından yayımlanan Radyo Frekanslı Elektromanyetik Alanların (RF-EMF) insan sağlığına etkileri araştırılmaya başlanmıştır. Bu araştırmaların bir kısmında RF-EMF'nin insan sağlığına zararlı etkileri açıklanmış olsa da diğerlerinde insan sağlığına etkilerinin sınırlı olduğu belirtilmiş ve bu nedenle çelişkili sonuçlar ortaya çıkmıştır. RF-EMF'ler, insan dokularına enerji aktararak, sıcaklığı artırarak ve hücre zarlarının çalışma şeklini değiştirerek etkilere sahip olabilir. Bu etkiler ise MPBS'lerin yerleşim yerlerine yakınlığı ve güvenlik mesafeleri ile ters orantılı olarak değişebilmektedir. Bu konuda nüfus yoğunluğunun fazla olduğu yerlerden (okul, hastane, AVM vb.) en az 300 m uzakta ve yerden en az 40 m yüksekte konumlandırılması gibi kurallar gerekmektedir. Bu çalışmada, özgün olarak Türkiye'de hem Rize kent merkezinde hem de kırsal bölgelerde kurulu baz istasyonlarının farklı 4.5G frekans bantlarında (GSM 900 DL- 1800 DL-2100 DL) RF-EMF değerleri, gerçek zamanlı seçici alan analizörü (NARDA-SRM 3006) kullanılarak ölçülür. Bu baz istasyonlarının üretim/etiket değerlerindeki emniyet mesafeleri, matematiksel olarak hesaplanan EMF ve ölçüm değerleri farklı mesafeler için karşılaştırılmıştır. Kent merkezleri ve kırsal bölgelerde MPBS'lerin yaydığı RF-EMF değerlerinin baz istasyonu üretim/etiket ve gerçek zamanlı ölçüm değerleri belirlenerek insan sağlığına etkileri değerlendirilmektedir.

Anahtar Kelimeler: Cep Telefonu Baz İstasyonları, Elektromanyetik Alan, İnsan Sağlığı, Kırsal Alanlar Radyo Frekansı, Şehir Merkezleri.

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INTRODUCTION

In recent years, it has been observed that in mobile communication the number of base stations in areas where people are concentrated has increased rapidly. This is due to the fact that parameters such as developing technology and increasing population density increase the need for mobile communication. The increase in the number of base stations in crowded city centers such as schools, hospitals and shopping centers trigger the concerns that it will continuously create in human health.

In the international arena, conditions such as RF-EMF emitted by base stations, their effects on human health, MPBS-installed locations, frequency ranges and safety distances have been determined by certain standards.[1-4]

For example, the highest electric field strength value determined by ICNIRP (International Commission on Non-Ionizing Radiation Protection) for RF-EMF base stations on the European scale for base stations operating in the 900Mhz frequency range is 41 V/m. In Turkish standards, this value is 28.7 V/m, which is 70% of the ICNIRP value in environments, and 8.2 V/m, which is 20% of the ICNIRP value in devices.[2]

As can be seen from the standards, certain criteria have been identified to reduce or eliminate the effects of RF-EMF values broadcast from base stations on human health. Besides, the effects of base stations on human health have been discussed in many studies from different perspectives. In the studies conducted in different countries and cities in the international arena, in addition to making personal measurements and surveys, evaluations were made with real-time measurements depending on the density of people in general.

In a study conducted in France, human exposure to RF-EMF was applied to 354 participants. In the measurements made on 152 people and others using a personal exposure meter, the exposure measurements in humans showed that the value was 0.58-0.44 V/m, and the RF-EMF value emitted by the base station of the environment was 0.43-0.27 V/m. In this first study conducted in France, it was suggested that the effects of RF-EMF values on human health should not be excluded with spot measurements.[5]. A similar study examined the measurement and human health effects of base station RF-EMF values in the 900MHz frequency band in Australia and Belgium. However, it was concluded that the obtained values were below the danger values.[6]

In another study conducted in France, the relationship between RF-EMF exposure measured from MPBSs and the presence of self-reported nonspecific and insomnia-like symptoms was investigated. In the research conducted in five big cities between 2015 and 2017, 354 people were surveyed. In this study population, exposure measured from MPBSs was 0.27 V/m; it was evaluated that the exposure was not associated with a person's reported nonspecific or insomnia-like symptoms, and for insomnia-like symptoms, there was a significant interaction between exposure to RF-EMF from MPBSs and environmental concerns.[7]

In the Netherlands, RF-EMF effects were determined from base stations in a 24-hour period with exposure measurements made on 93 individuals. Accordingly, it was stated that although it was lower than previous epidemiological studies, important statistical data on the effects of RF-EMF exposure were obtained.[8]

In a study in Spain on the relationship of RF-EMF values emitted by base stations with headaches, sleep and nightmares in a Madrid neighborhood with nine base stations in Madrid, both inside and outside houses, it was determined that people exposed to higher radiation values had more severe headaches, dizziness and nightmares, and they slept fewer hours.[9]. In this study, it was determined that RF-EMF values affect human health.

Similarly, a study conducted in Sweden examined an area on Skeppsbron street in Stockholm, where the base station antennas were placed low near the heads of pedestrians.

In the resulting measurements, the highest measured average EMF from the area was 12.1V/m, while the highest average EMF value of 31.6V/m was measured from all areas. It was determined that most of these EMF values originated from the services operating in the 2100 MHz-2600 MHz band originating from the base station.[10]. Here, it was evaluated that the base stations emitted higher EMF values each day (3G → 4G → 5G…).

In a study that showed that RF-EMF emitted by base stations had an effect on human health and even further caused cancer, three types of effects of base station antennas on people's health were mentioned, and these were indicated as radio frequency disease (RS), cancer (C) and changes in biochemical parameters (CBP). As a result of the data obtained from all studies examined globally, it was determined that RF-EMF values affect human health. In addition, it has been emphasized that humans, animals and trees in their habitat are in danger.[11].

In a statistical study, it was concluded that the RF-EMF values of the surveyed base stations damaged the trees nearby as well as human health. The measurement results obtained in this study showed that the RF-EMF values emitted by the base station started from one side of the tree and spread to the entire tree.[12]

In addition to these studies, a study on the distance of GSM (Global System for Mobile Communication) base stations from settlements and their effects on human health[13] and studies on disease statistics when exposed to RF-EMFs of base stations[14-16] were examined.

In these previous studies, the effects of base station RF-EMF values in a particular country and location in a city of this country or in a certain area on human health were evaluated. It was concluded that the operating frequency ranges of these base stations were not generally classified, to what extent the safety distances were affected in case of differences in the places of use were not identified, and the comparative studies were limited.

In this study, real-time measurements of RF-EMF values were made in the city center where the MPBS was installed, where the population density was high, and in the rural areas where the density was less. By comparing the RF-EMF values and measurement results corresponding to the data in the production/label values included in the security certification of the base stations, the compliance of these values with the safety distances determined by international (E=41.25(V/m)) and national standards (E=10.23(V/m)) was determined. In light of the current data together with these valuations, it will be possible to evaluate the real-time measurements of the city center and rural values that will serve as a cause concern for human health.

MATERIAL AND METHOD

MPBS Selections and Installation Areas

An electromagnetic field is the effects of signals operating in different frequency ranges. These signals settle in the spectrum from which the signals propagate, from the low frequency range to the high frequency range, such as radio, microwaves, infrared, ultraviolet and visible light, and X and Gamma rays. The placement of these signals in the spectrum is seen in.[1] Here, it is observed that the signals with the highest frequency are X and Gamma rays.

When the effects of radiation on human health that occur in the rays located in the ionized zone were examined, it was identified that they caused chromosomal changes such as cell changes, cancer, etc.[17]

In this study, radio waves emitted from the base stations in the section of non-ionizing waves, may cause an increase in temperature or changes in the working styles of cell membranes by transferring their energy to the tissues they enter in the human body.

With these aspects, the increasing number of base stations with the increasing need for and

the development of technology in recent years causes a disturbance in areas where people live intensively.

In the study where the effects of RF-EMF values of base stations on human health were considered due to this disturbance, it is aimed to conduct a study by considering the regions selected as the Rize city center and rural areas in the Black Sea Region in Turkey where the living spaces of people are absolutely scanned in both locations.

Real-time measurements of the base stations located in the city center were captured as can be seen in Figure 1.

These base stations were located in the city center with a population density of approximately 0-30000 people. Base stations serve in the determined frequency bands of different GSM operators. The label data of these base stations are given in Table 1.

Table 1. Product data of Base Stations in Rize Center in Turkey

Base Station	Height of Antenna from Ground (m)	Antenna Gain (dB)	Max. Power (W)	Frequency of the System (MHz)	Safety Distance (m)
Base Station 1	32.5	14.2	20	900	13.73
Base Station 2	17.2	17	20	900	13.42
Base Station 3	17.2	17	20	1800	14.86

Figure 1. Base Stations of Different Operators at Rize Center in Turkey

Real-time measurements were obtained of the base stations located in the rural area as seen in Figure 2.

Figure 2. Base Stations of Different Operators in Black Sea Region Rural Area in Turkey

These base stations located in the Rural Area of the Black Sea Region at different distances from the city center of Rize are communication tools with different features and system frequencies owned by different GSM operators operating in the country. The specifications of these MPBSs are listed in Table 2.

Table 2. Product data of Base Stations at Rize Center in Turkey

Base Station	Height of Antenna from Ground (m)	Antenna Gain (dB)	Max. Power (W)	Frequency of the System (MHz)	Safety Distance (m)
Base Station 4	18.7	18	40	2100	20.38
Base Station 5	17.2	17.5	30	1800	15.55
Base Station 6	18.7	14.4	20	900	12.57

Base stations located in the city center were established on the roofs of buildings, while the base stations in the rural areas were established in independent areas due to space availability. Real-time measurements were made in an area of 0-55.4 meters considering the safety distances of the base stations in the city center. The measurements in the rural areas, on the other hand, were made in an area of 0-74 meters in diameter in terms of the safety distances of the base stations. While

choosing these distances, the area where there was a density of people that could be exposed to RF-EMF emitted from the base stations and the maximum coverage area that could be exposed to the signals were selected.

In these coverage areas, the density of people was continuous in the region where both base stations were installed, and the density of the city center was higher than in the rural region.

RF-EMF Exposure Measurement

The measurements taken from the base stations in the areas selected in the study were carried out according to the regulations of the Information Technologies and Communications Authority, which is responsible for determining the standards in the inspection and measurement of the devices used in the communication of electronic devices in Turkey.[2] The application principles in this regulation were prepared based on the limit values in the Guide prepared by the internationally recognized ICNIRP, besides, a special limitation was introduced for each base station. The limit values contained in the regulation of the Information Technologies Authority for general living areas in the frequency band of 400-2000 MHz for a single device in Turkey are given as $0.341*\sqrt{f}$ V/m (f = frequency (MHz)) for the electric field intensity, as $0.0009*\sqrt{f}$A/m for the magnetic field intensity and as f/80 W/m^2 for the power density. These limit values are the average values obtained after six minutes of measurement. In Turkey, where these data are used, the observed limit values at 900 MHz and 1800 MHz are given in [2].

In [2], a RF-EMF table prepared for some frequently used frequencies is given. The values of Electrical field(E), magnetic field(H), magnetic flux(B)and power density are given both limit value for a single device (LS) and total value of the environment (TE).

At the same time,limit values are given for some valid frequency ranges of Turkey are given in [2].

Considering the values of this values, as stated in the Regulations of the Information Technology and Communications Authority, the radiation values in the base stations in Turkey are based on the limit values determined by ICNIRP of 70% in a single device.

These values in the table are safe area distances determined by considering national and international standards. In the study, the average values determined by the measurement values taken from three points with a precision of 0.8-1.2-1.6 m for each location within an area of 0-55.4 m in diameter for city-centered areas and the measurements of the distances (right-left-up) in at least three different directions of the average 0-10 points around the base station as specified in the standards were recorded.

Measurements were made with a selective field analyzer (NARDA) consisting of a SRM 3006 main unit and three measuring probes. This equipment allowed accurate measurement of each frequency in the 100 KHz - 6 GHz band. These frequencies were measured in channel strength mode for each type of service provided, and a quadratic aggregate value was calculated for each service for all non-adjacent bands. This equipment calculates average square root measurements of electric field density with an average sensitivity of 0.001 V/m. During the measurement, all interior resources (WiFi, Dect, etc.) were measured explicitly and checked whether the operator base station antenna appeared from the house.

In the real-time measurement results, values of RF-EMF emitted from base stations were compared with theoretical data. The electric field power equation to obtain the data for this comparison was included in the ICNIRP standards. The equation specified in the Regulation of the Information and Technology and Communication Authority in Turkey is given in Equation 1 and the results of these equations were used in comparison with real-time data.

$$d = \frac{\sqrt{30.P.10^{G/10}}}{E} \quad [1]$$

P (W) refers to the antenna max power, G (dB) antenna gain, D (m) safety distance and E (V/m) electric field strength.

RESULTS AND DISCUSSION

Evaluation of the Measurements and Results Obtained in Base Stations in the Urban Center

In the study, real-time data were obtained from the devices of the base stations established in the Rize urban center in the Black Sea region in Turkey with different security certification data belonging to different operator companies.

According to these data, graphics drawn from the minimum E (V/m) value and Max E (V/m) values of the real-time data obtained from the base stations and the values obtained according to the label values in Table 1 in the formula given in Equation 1, are given in Figure 3.

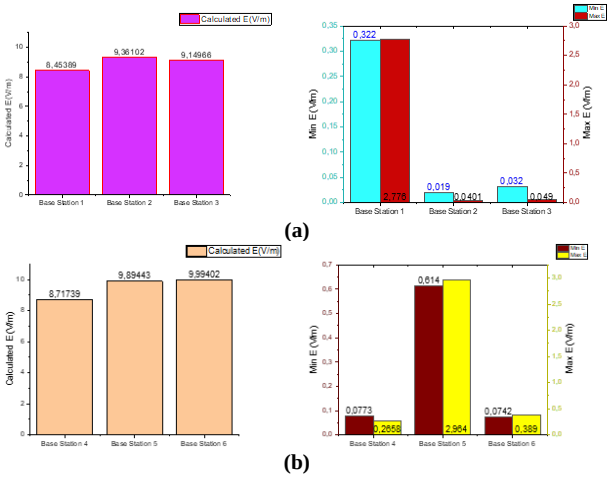

Figure 3. (a)Base Stations Electric Field Strength Values of Different Operators in the Rize Urban Center in Turkey

(b) Base Stations Electric Field Strength Values of Different Operators in Rural Area of Black Sea Region in Turkey

When the data in Figure 3(a) were examined, it was observed that the value specified in the security certifications of these base stations in the urban center and the electric field strength values calculated in the frequency range (900mHz DL) were close to each other. However, in real-time measurements at a distance of 0-55.4 meters, it was determined that more electric field intensity was emitted from the 1st base station than the others. Along with the values of other base stations, all values were measured well below the value ranges that affect human health.

As seen in Figure 5, among the values taken from about 10 different points, the highest E (V/m) value at the base stations was obtained from base station 1 with 2.776 V/m. The value specified in European standards, and which has a harmful effect on human health has been determined as 41.25 V/m, and this value is applied as 10.23 V/m for a single device in Turkey. It has been determined that the values in real-time measurements are approximately five times lower than the values in Turkey at one base station, and 250 times lower on average than the others. This result shows that the effect of RF-EMF values emitted from base stations in urban centers on human health is below the determined values and has a limited effect.

Measurements Made at Base Stations in Rural Areas and Evaluation of Obtained Results

At this stage of the study, real-time measurements were made for base stations established in rural areas and in places where the human density was lower than the city center. These base stations, like the base stations in the city center, were the base stations of different operators, and the system frequencies were different depending on their location in the rural areas and the transportation demand of the operators in the region (900MHz-1800MHz-2100MHz).

The data calculated with the values obtained from the E (V/m) value and the security certifications measured from the base stations in the rural area are given in Figure 5(b).

As seen in Figure 5(b), the obtained E (V/m) values were far below the theoretical data obtained from the safety certification data of the devices, as well as the international 41.25 V/m determined in the standards and the 10.23 V/m value in the Turkish standards. Accordingly, although the system frequencies were high in rural areas, the effects of the electric field strength values emitted from the base stations on human health were also limited.

Real time values of this rural area analyze obtained in the measurements of the E (V/m) values within the 0–74-meter diameter area around the base station were measured as 2.964 V/m, which corresponds to a maximum of 30% of the national standard values. In international E (V/m) values, this value corresponds to 7.1%.

CONCLUSION AND RECOMMENDATIONS

Mobile communication is aimed at ensuring smooth communication over a range of certain distances with the gravitational force generated by base stations. The installation and certification of base stations used for this purpose have been governed by certain standards. These standards are the values set by ICNIRP in most European countries. In Turkey, based on these standards, operators providing mobile communication services interpret and apply them in accordance with the functioning of the country for the base stations they want to establish.

Considering these standards, the installation area of base stations may be in city centers and/or in rural areas. In most of the studies in the literature, the data of the base stations in the city centers, and the security certification data of which are not highly evaluated, were examined. These examinations were in the form of statistical interpretations of the data obtained with personal exposure meters or in the form of interpretation of the data obtained with the spectral analyzer of the ambient data. From these data, evaluations have also been made on the effect of electric field strength values emitted from base stations on human health, which some sources characterize as contradictory.

In this study, the Black Sea region analysis was carried out in Turkey, where the density of life in rural areas, which is also rare in international geographies, is high. Here, measurements were taken with real-time spectral analyzer from 4.5G base stations both in a city center and in areas with a high density of people in rural areas. These data are compared with the analytical data obtained from the security certificate data specified in the standards applied depending on the location of the base stations.

It was determined that the E (V/m) values measured from base stations both in the city center and in rural areas with a high density of people due to tea cultivation, transmit up to 30% of the values determined by the standards. In addition, it has been determined that the rural area E(V/m) values are 6% more intense than the maximum measurement values according to the city center values. It was observed that the E (V/m) values calculated with the label data in the analytical formula were also approximately 10% below the standard values, and the E (V/m) values emitted by the base stations were considered to have a low impact on human health.

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