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Measurement of Electromagnetic Pollution in Adıyaman City Centre

Ömer SÖĞÜT[1,*], Şükrü KARADENİZ[2]

[1]*Kahramanmaraş Sütçü İmam University, Faculty of Arts and Sciences, Department of Physics, 46100 Kahramanmaraş, Türkiye, osogut@ksu.edu.tr*

[2] *National Education Ministry, Besni Şehit Abidin Tanrıkolu Anatolian High School, 02300 Besni-Adıyaman, Türkiye, karadenizsukru@hotmail.com*

Abstract

In this study, the measurements of the electric field strength, magnetic field strength and the equivalent plane wave power density in 24 different locations, with 250 m intervals, throughout Atatürk Boulevards (5750 m) in the centre of Adıyaman province were performed. Spectran HF-60105 V4 portable spectrum analyzer was used to measure the electric field strengths (E), magnetic field strengths (H) and the equivalent plane wave power densities (S) in selected locations. Measurements were performed on the same day and at the same locations for two different time intervals including one in the morning (10.00-12.00) and another in the afternoon (17.00-19.00). Each measurement lasted at least six minutes as advised by national and international organizations to obtain a significant result. The obtained results were compared to the limit values defined by the Turkish Information Technologies and Communications Authority (BTK), International Non-Ionizing Radiation Protection Commission (ICNIRP) and Institute of Electrical and Electronics Engineers/Federal Communications Commission (IEEE/FCC). It was determined that all of the values obtained from measurements (E, H and S) were smaller than the limit values for non-ionizing radiation as defined by national and international institutions such as BTK, ICNIRP and IEEE/FCC.

* Corresponding Author

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Keywords: Base Station, Radiation, Mobile Phone, Human Health, ICNIRP, BTK, FCC.

Adıyaman İl Merkezinde Elektromanyetik Kirliliğin Ölçülmesi

Özet

Bu araştırmada, Adıyaman il merkezinde Atatürk Bulvarı boyunca (5750 m) 250 m aralıklarla, 24 farklı yerlerde elektrik alan şiddeti (E), manyetik alan şiddeti (H) ve eşdeğer düzlem dalga güç yoğunluğu (S) ölçümleri yapıldı. Seçilen yerlerde elektrik alan şiddetini, manyetik alan şiddetini ve güç yoğunluğunu ölçmek için, Spectran HF-60105 V4 taşınabilir spektrum analizörü kullanıldı. Ölçümler, aynı yerde aynı gün içerisinde sabah 10.00-12.00 ve öğleden sonra 17.00-19.00 saatlerinde olmak üzere günde iki kez yapıldı. Her bir ölçümün anlamlı olabilmesi için ulusal ve uluslararası kurumların önerdiği gibi, ölçümler en az altışar dakika boyunca yapıldı. Bulunan sonuçlar, Türkiye Bilgi Teknolojileri ve İletişim Kurumu (BTK), Uluslararası İyonlaştırıcı Olmayan Radyasyondan Korunma Komisyonu (ICNIRP) ve Elektrik ve Elektronik Mühendisleri Enstitüsü/Federal İletişim Komisyonu (IEEE/FCC) tarafından belirlenen limit değerleri ile karşılaştırıldı. Ölçümlerden elde edilen değerlerin tamamının (E, H ve S) BTK, ICNIRP ve IEEE/FCC gibi ulusal ve uluslararası kurumlar tarafından belirlenen limit değerlerden daha küçük olduğu tespit edildi.

Anahtar Kelimeler: Baz İstasyonu, Radyasyon, Cep Telefonu, İnsan Sağlığı, BTK, ICNIRP, FCC.

1. Introduction

Global System for Mobile Communications or briefly, GSM is a mobile communication system. GSM was first used worldwide in Finland. Finland wired communication has started to work on the mobile system as an alternative and they made their first experiments on the system in 1982 since its geographical structure, weather conditions and settlement are very scattered [7, 20, 21]. Wireless telecommunications need a large network of mobile phone towers (base stations) to send and receive information. The cellular telephone towers are made up of antennas and electronic devices that serve local wireless networks. The mobile phones are now an integral part of modern communication. The mobile phones are low-energy radio frequency transmitters operating at peak frequencies between 0.1 and 2 watts with frequencies between 450 and 2700 MHz.

All cell phones emit a type of radiation called an electromagnetic field (EMF), composed of waves of electric and magnetic energy moving together through space [25]. The radio frequency (RF) is a part of the electromagnetic spectrum consist frequencies in the range of about 3 kilohertz (3 kHz) to 300 gigahertz (300 GHz). If a radiation has enough energy to move or vibrate the atoms but if this energy is insufficient to remove the atom's electrons, this radiation is called non-ionizing radiation. Among the sources of non-ionizing radiation may be counted mobile phones, radios, and television transmitters, various devices used in medical and industrial applications, and small electronic devices used in homes [25]. Nowadays young children are using them, teenagers live on them, and some even sleep with them under their pillows, as cell phones are often used as alarm clocks. Cell phone technology has changed quickly recently and continues to develop, which means that human exposures also will be changed over time. In recent years, there are not only mobile phones that have entered our lives and intertwined with us, but also many other electronic devices such as microwave ovens, and wireless internet (wifi). While these and similar devices have made life easier, they have carried the danger with them. For example, all of the devices from television used for telecommunication to mobile phones, and from X-ray devices used for diagnostic and therapeutic purposes to laser devices used for various applications are caused us to be exposed to a certain amount radiation dose [20, 25]. Moreover, a number of mobile phone towers (base stations) with narrow coverage for quality communications in residential areas were established. As a result, people, animals and plants, in short, are all under the influence of environmental electromagnetic fields or electromagnetic pollution. The increasing use of mobile phones having among the electromagnetic (EM) radiation sources has need to a comprehensive investigation of the effects on health [26]. The electromagnetic pollution is neglected because it is not visible to the contrary of other pollutants and its effects do not appear in a short time. The mobile phones radiate low levels of radio frequency (RF) energy and some part of them are absorbed by our body. The RF energy absorbed by our body depends on many factors such as the signal strength and distance of the mobile phone from our body. But, a human has a very complex neural network about

500,000 km in length and about 25 billion cells. This complex network communication performs physical functions with very small voltages in between 1-250 micro volts. Any electromagnetic interference that may be came from outside to this complex structure can affect the circulation and nervous system, causing deterioration of the circulatory system and weakening of the immune system. Since this is defined by medical experts as a risk of cancer the danger is too great to be neglected [11, 26]. The age of mobile phone user in our country has been fallen to the level of primary school and even lower, due to the widespread use of mobile phones and some applications such as games. Therefore, the electromagnetic pollution caused by mobile phones, that is, non-ionizing radiation affect children in the age of development rather than adults [27]. In 2011, WHO's International Agency for Research on Cancer (IARC) classified electromagnetic fields as possibly carcinogenic to humans, based on an increased risk for glioma, a malignant type of brain cancer, associated with mobile phone [12, 17, 28]. As a result of non-ionizing electromagnetic wave exposure in the environment, two types of effects can occur in living things to be thermal effects and non-thermal effects. Thermal effects are defined as the conversion of the electromagnetic energy absorbed by the body into heat and increase the body temperature [24]. There are the variation of the brain activities, sleep disorders, attention disorders, headaches and electromagnetic sensitivity among the discomforts alleged to be influenced by radio waves (RF) depending on non-thermal effects [23]. Some researchers have said that mobile phone use may be affect the human nerve and reproductive system, cause DNA damage and behavioural changes, or create behavioural dependence [25]. A study related to the effect of mobile phone usage on sleep quality was done by Mollaoğlu et al. [18] and they reported that the use of mobile phone by individuals have negative impact on sleep quality. A research related to the effects of electromagnetic waves on human biochemistry was done by Yağmur et al, and they have concluded that it is not certain whether the electromagnetic waves are harmful or not to human health [22]. Additionally, the antibacterial effects of electromagnetic waves emitted by mobile phones were also investigated and E. coli and B. subtilis bacteria were reported to be influenced by electromagnetic waves [2]. It should be noted that the presence of base stations in buildings where children, patients and other risk groups are living may be detrimental to health [19]. But, the effects of exposure of the human body to the electromagnetic field (EM) from outside are generally dependent on the frequency and magnitude of the EM or power of the EM. At low frequencies, while the radio frequency fields are partially absorbed and penetrated into the tissue only at a short depth, EM passes through the body. Low-frequency electric fields affect the distribution of electrical charges on the surface of conducting tissues and cause electrical current to flow through the body. However, Low-frequency magnetic fields cause currents to circulate in the human body. The power of these induced currents depends on the magnitude of the external magnetic field and the size of the current loop through the current. They can cause nerves and muscles to be stimulated when these currents are large enough [24, 29]. There have been various studies reported previously in the literature about the effects of electromagnetic radiation and mobile phones on human health [1, 3-6, 8, 9, 16].

In this study, the measurements of the electric field strength (E), magnetic field strength (H) and equivalent plane wave power density (S) using a Spectran HF-60105 V4 portable spectrum analyzer and MCS-coded software were performed to determine the electromagnetic pollution on the Atatürk Boulevard in the city centre of Adıyaman.

2. Material and Method

The measurements of electric field strength, magnetic field strength and equivalent plane wave power density of radiofrequency origin electromagnetic waves broadcast from base stations at frequencies of GSM900 MHz downlink, GSM1800 MHz downlink and UMTS (3G) 2100 MHz in 24 different locations, with 250 m intervals, throughout Atatürk Boulevard (5750 m) in the centre of Adıyaman province were performed. Aaronia spectran HF-60105 V4 portable spectrum analyzer having with frequency range of 1 MHz to 9.4 GHz was used to obtain the measurements. Each measurement at the same location lasted at least for 6 minutes in line with BTK and ICNIRP proposal in order for the measurements to constitute a meaningful result. Each measurement was repeated three times and averaged [10, 13]. In these measurements, Spectran Aaronia HF-60105 V4 Handheld Spectrum Analyzer with 1MHz-9.4GHz frequency range and the feature of the frequency filtering were used. Thus, only, the measurement of the electric field intensity, magnetic field strength and equivalent plane wave power density of the selected frequency was performed with accuracy of ±1 dB (decibel). The characteristics of the Aaronia spectran HF-60105 V4 portable spectrum analyzer is given in Table 1 and the photograph of the device is also given in Figure 1. The map of measurement locations selected at intervals of 250 m along Atatürk Boulevard has been presented in Figure 2.

Table 1. Selected some features of the Aaronia spectran HF-60105 V4 portable spectrum analyzer.

Frequency range	1 MHz-9.4 GHz
DANL	-155 dBm(1Hz)
The maximum measurement range	-170 dBm(1Hz)
Preamplifier	-150 dBm (1Hz
Max Power at RF input	20d Bm (opt. +40 dBm)
Lowest sample time	5 ms
RBW (resolution bandwidth)	200 Hz to 50 MHz
EMC filter	200 Hz, 9 kHz, 120 kHz, 200 kHz, 1,5 MHz, 5 MHz
Units	dBm, dBµV, V/m, A/m, W/m² (dBµV/m etc. via PC software)
Detectors	RMS, Min/Max
Demodulator	AM, FM, PM, GSM
Introduction	50 Ohm SMA RF-input (f)
Accuracy (typical)	±1dB (typ.)
Interface	USB 2.0/1.1
14Bit Dual-ADC & DDC Hardware-Filter	
DDC hardware filter	
150 MIPS high performance DSP (Digital Signal Processor)	
Spectrum display (51x25 pixel)	

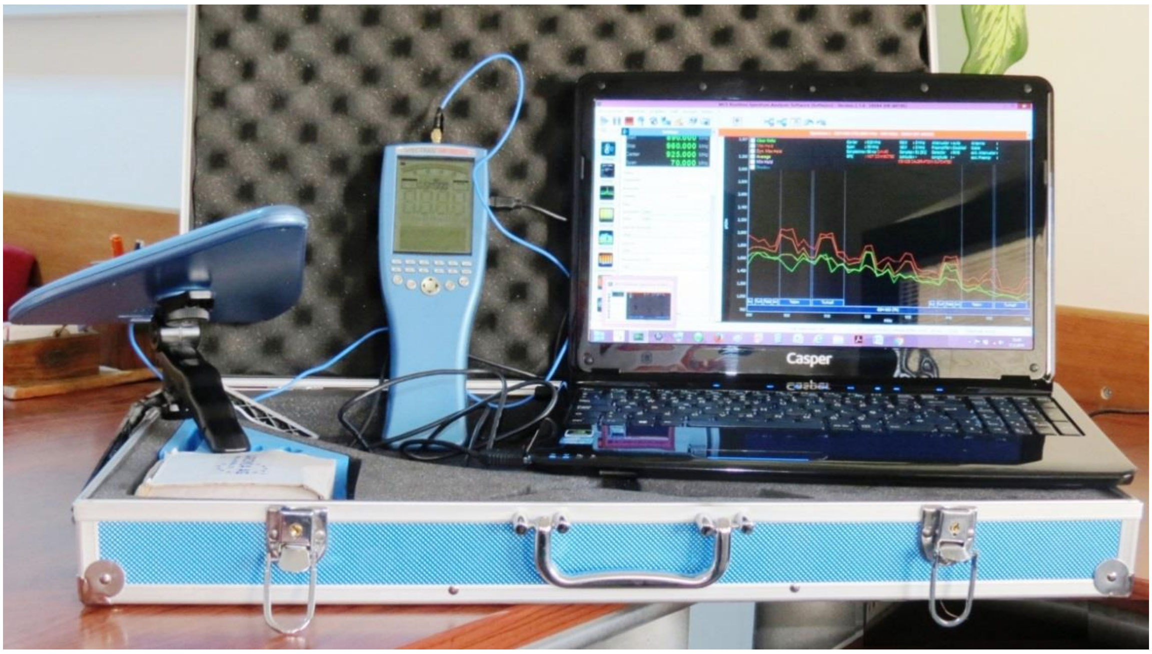

Figure 1. Aaronia Spectran HF-60105 V4 portable spectrum analyzer and a laptop with MCS software (Söğüt, 2016).

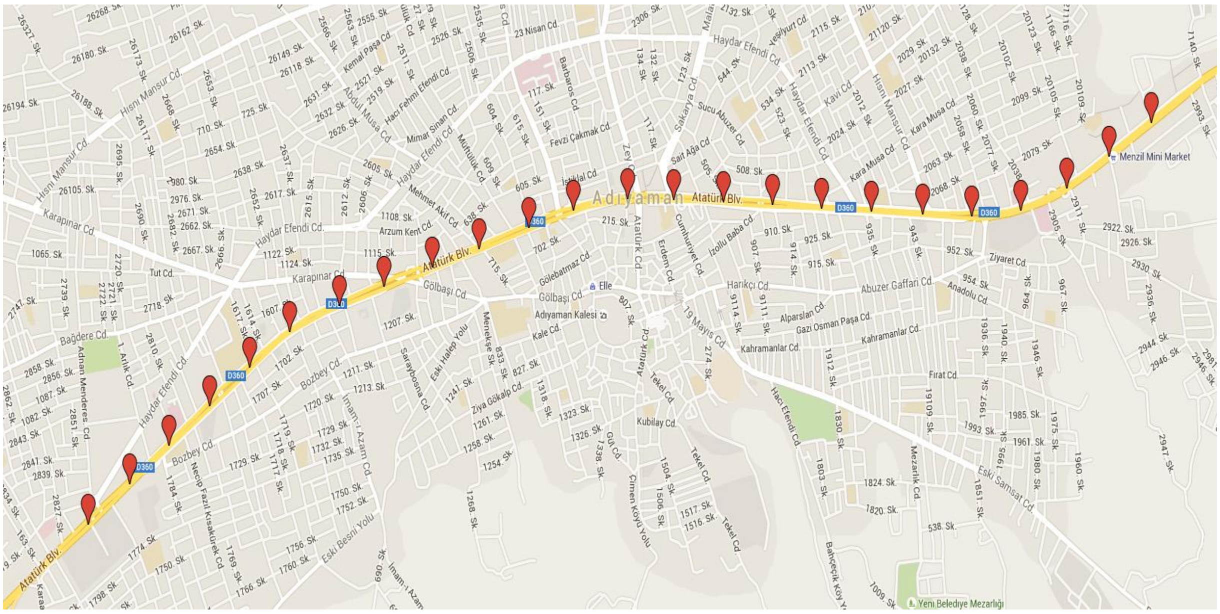

Figure 2. Map of the measurement locations made along Atatürk Boulevard in Adıyaman city centre.

3. Results and Discussion

The measurements of electric field intensity, magnetic field strength and equivalent plane wave power density of radiofrequency origin electromagnetic waves emitted from base stations at 24 different locations on GSM900 MHz downlink, GSM1800 MHz downlink and UMTS (3G) 2100 MHz were made twice on the same day, one in the morning and another in the afternoon to determine the level of electromagnetic pollution on the Atatürk Boulevard in Adıyaman city centre. Results obtained using Aaronia spectran HF-60105 V4 portable spectrum analyzer and a laptop computer is given in Table 2-4. The limit value for the equivalent plane wave power density (S) for 30 minutes exposure non-ionizing radiation has been defined by IEEE / FCC [10, 13] as 6 W/m^2. In addition, the limit value of the equivalent plane wave power density (S) for 6 minutes exposure non-ionizing radiation is defined as 4.5 W/m^2 by both ICNIRP [14] and BTK [15]. As seen from Table 2-4, it was detected that the measured values of the electric field strength, the magnetic field strength and the equivalent plane wave power density at all of locations in both morning and afternoon are smaller than the limit values defined by BTK [15], ICNIRP [14] and IEEE/FCC [10, 13]. But, the fact that the values found are below the limit values does not mean that they are totally harmless. Because exposure time is also important as much as the intensity of the exposed radiation. However, the results of long-term exposure to radiofrequency electromagnetic waves are still not fully established.

Table 2. The values of the measurements performed with Aaronia Spectran HF-60105 V4 Portable Spectrum Analyzer at GSM 900 MHz downlink frequency between 10.00-12.00 and 17.00-19.00 hours. [E (mV/m), H (mA/m), S (mW/m^2)].

Measuring locations	Coordinates (Lat., Lon.)	Measurements made between 10.00-12.00 hours			Measurements made between 17.00-19.00 hours			ICNIRP [27] Limit values for 6 minutes			BTK [26] Total limit values of the environment		
		E	**H**	**S**	**E**	**H**	**S**	**E**	**H**	**S**	**E**	**H**	**S**
Location 1	37.752, 38.246	86.07	0.2283	1.97 x10^{-2}	106.8	0.2833	3.03 x10^{-2}	41250	111	4500	41250	111	4500
Location 2	37.754, 38.248	868.6	2.304	2.0013	146.9	0.3897	5.72 x10^{-2}						
Location 3	37.755, 38.251	511.9	1.3578	0.6951	831.8	2.2064	1.8353						
Location 4	37.756, 38.253	6.8728	1.82 x10^{-2}	1x10^{-4}	393	1.0424	0.4097						
Location 5	37.758, 38.255	65.79	0.1745	1.15 x10^{-2}	17.37	4.61x10^{-2}	8x10^{-4}						
Location 6	37.759, 38.257	597	1.5836	0.9454	154.3	0.4093	6.32 x10^{-2}						
Location 7	37.759, 38.260	19.82	5.26 x10^{-2}	1x10^{-3}	671.3	1.7806	1.1953						
Location 8	37.761, 38.263	15.72	4.17 x10^{-2}	7 x10^{-4}	76.39	0.2026	1.55 x10^{-2}						
Location 9	37.761, 38.266	41.96	0.1113	4.7 x10^{-3}	19.16	5.08 x10^{-2}	1x10^{-3}						
Location 10	37.762, 38.268	187.2	0.4966	9.3 x10^{-2}	146.2	0.3878	5.67 x10^{-2}						
Location 11	37.763, 38.271	435.6	1.1554	0.5033	151.8	0.4027	6.11 x10^{-2}						
Location 12	37.763, 38.274	230	0.6101	0.1403	143.8	0.3814	5.49 x10^{-2}						
Location 13	37.764, 38.277	90.91	0.2411	2.19 x10^{-2}	560.5	1.4867	0.8333						
Location 14	37.764, 38.279	86.07	0.2283	1.97 x10^{-2}	167.8	0.4451	7.47 x10^{-2}						
Location 15	37.764, 38.282	359	0.9523	0.3419	85.9	0.2279	1.96 x10^{-2}						
Location 16	37.763, 38.285	538.7	1.4289	0.7698	644.1	1.7085	1.1004						
Location 17	37.763, 38.288	72.8	0.1931	1.41 x10^{-2}	194.6	0.5162	0.1004						
Location 18	37.763, 38.291	111	0.2944	3.27 x10^{-2}	113.9	0.3021	3.44 x10^{-2}						
Location 19	37.763, 38.294	385.9	1.0236	0.3950	130.2	0.3454	4.5 x10^{-2}						
Location 20	37.760, 38.296	189.9	0.5037	9.57 x10^{-2}	217.7	0.5775	0.1257						
Location21	37.763, 38.299	184.8	0.4902	9.06 x10^{-2}	138	0.366	5.05 x10^{-2}						
Location22	37.764, 38.302	195.6	0.5188	0.1015	129.5	0.3435	4.45 x10^{-2}						
Location 23	37.765, 38.304	391.7	1.0390	0.4070	345.2	0.9157	0.3161						
Location 24	37.766, 38.307	68.7	0.1822	1.25 x10^{-2}	115.7	0.3069	3.55 x10^{-2}						

Table 3. The values of the measurements performed with Aaronia Spectran HF-60105 V4 Portable Spectrum Analyzer at GSM 1800MHz downlink frequency between 10.00-12.00 and 17.00-19.00 hours. [E (mV/m), H (mA/m), S (mW/m^2)].

Measuring locations	Coordinates (Lat., Lon.)	Measurements made between 10.00-12.00 hours			Measurements made between 17.00-19.00 hours			ICNIRP [27] Limit values for 6 minutes			BTK [26] Total limit values of the environment		
		E	**H**	**S**	**E**	**H**	**S**	**E**	**H**	**S**	**E**	**H**	**S**
Location 1	37.752, 38.246	0.8015	$2.2x10^{-3}$	$2x10^{-6}$	0.7653	$2x10^{-3}$	$2x10^{-6}$	58340	157	9000	58340	157	9000
Location 2	37.754, 38.248	1.0982	$2.9\ x10^{-3}$	$3x10^{-6}$	20.8	$5.52x10^{-2}$	$1.15x10^{-3}$						
Location 3	37.755, 38.251	1.9328	$5.1\ x10^{-3}$	$1x10^{-5}$	178.7	0.474	$8.47x10^{-2}$						
Location 4	37.756, 38.253	0.7116	$1.9\ x10^{-3}$	$1x10^{-6}$	1.1314	$3x10^{-3}$	$3x10^{-6}$						
Location 5	37.758, 38.255	2.0713	$5.5\ x10^{-3}$	$1.1x10^{-5}$	34.59	$9.18\ x10^{-2}$	$3.17x10^{-3}$						
Location 6	37.759, 38.257	7.3743	$1.96x10^{-2}$	$1.44x10^{-4}$	2.7066	$7.2\ x10^{-3}$	$1.9x10^{-5}$						
Location 7	37.759, 38.260	152	0.4032	$6.13x10^{-2}$	3.6173	$9.6\ x10^{-3}$	$3.5x10^{-5}$						
Location 8	37.761, 38.263	475.3	1.2607	$5.99x10^{-1}$	1.9094	$5.1\ x10^{-3}$	$1x10^{-5}$						
Location 9	37.761, 38.266	1.1655	$3.1\ x10^{-3}$	$4x10^{-6}$	5.4754	$1.45\ x10^{-2}$	$8x10^{-5}$						
Location 10	37.762, 38.268	2.3002	$6.1\ x10^{-3}$	$1.4x10^{-5}$	1.0905	$2.9\ x10^{-3}$	$3x10^{-6}$						
Location 11	37.763, 38.271	151.8	0.4027	$6.11x10^{-2}$	1.3461	$3.6\ x10^{-3}$	$5x10^{-6}$						
Location 12	37.763, 38.274	1.4167	$3.8\ x10^{-3}$	$5x10^{-6}$	2.7738	$7.4\ x10^{-3}$	$2x10^{-5}$						
Location 13	37.764, 38.277	516	1.3687	$7.06x10^{-1}$	1.566	$4.2\ x10^{-3}$	$7x10^{-6}$						
Location 14	37.764, 38.279	0.8015	$2.1\ x10^{-3}$	$2x10^{-6}$	5.3115	$1.41x10^{-2}$	$7.5x10^{-5}$						
Location 15	37.764, 38.282	210.6	0.5586	$1.18x10^{-1}$	1.9639	$5.2\ x10^{-3}$	$1x10^{-5}$						
Location 16	37.763, 38.285	3.4368	$9.1\ x10^{-3}$	$3.1x10^{-5}$	3.0983	$8.2\ x10^{-3}$	$2.5x10^{-5}$						
Location 17	37.763, 38.288	1.2448	$3.3\ x10^{-3}$	$4x10^{-6}$	229.6	0.609	$1.4x10^{-1}$						
Location 18	37.763, 38.291	3.0721	$8.1\ x10^{-3}$	$2.5x10^{-5}$	1.971	$5.2\ x10^{-3}$	$1x10^{-5}$						
Location 19	37.763, 38.294	7.3246	$1.94x10^{-2}$	$1.42x10^{-4}$	7.9454	$2.11\ x10^{-2}$	$1.67x10^{-4}$						
Location 20	37.760, 38.296	79.73	0.2115	$1.69x10^{-2}$	71.18	0.1888	$1.34x10^{-2}$						
Location21	37.763, 38.299	78.33	0.2078	$1.63x10^{-2}$	48.24	0.128	$6.17x10^{-3}$						
Location22	37.764, 38.302	57.76	0.1532	$8.85x10^{-3}$	21.93	$5.82\ x10^{-2}$	$1.28x10^{-3}$						
Location 23	37.765, 38.304	52.54	0.1394	$7.32x10^{-3}$	30.16	$0.8\ x10^{-2}$	$2.41x10^{-3}$						
Location 24	37.766, 38.307	168.6	0.4472	$7.54x10^{-2}$	101.8	0.27	$2.75x10^{-2}$						

Table 4. The values of the measurements performed with Aaronia Spectran HF-60105 V4 Portable Spectrum Analyzer at UMTS 2100MHz (3G) downlink frequency between 10.00-12.00 and 17.00-19.00 hours. [E (mV/m), H (mA/m), S (mW/m^2)].

Measuring locations	Coordinates (Lat., Lon.)	Measurements made between 10.00-12.00 hours			Measurements made between 17.00-19.00 hours			ICNIRP [27] Limit values for 6 minutes			BTK [26] Total limit values of the environment		
		E	H	S	E	H	S	E	H	S	E	H	S
Location 1	37.752, 38.246	98.77	0.2619	$2.59 x 10^{-2}$	81.35	0.2158	$1.76 x 10^{-2}$	61000	160	10000	61000	160	10000
Location 2	37.754, 38.248	316.3	0.8390	0.2654	241.8	0.6414	0.1551						
Location 3	37.755, 38.251	256.9	0.6814	0.1751	460.9	1.2225	0.5635						
Location 4	37.756, 38.253	22.5	0.0597	$1.4 x 10^{-3}$	100.7	0.2671	$2.69 x 10^{-2}$						
Location 5	37.758, 38.255	103	0.2732	$2.81 x 10^{-2}$	18.61	$4.94 x 10^{-2}$	$9 x 10^{-4}$						
Location 6	37.759, 38.257	412.5	1.0942	0.4513	199.8	0.5300	0.1059						
Location 7	37.759, 38.260	575.7	1.5271	0.8791	645.3	1.7117	1.1045						
Location 8	37.761, 38.263	323.5	0.8581	0.2776	107.5	0.2851	$3.07 x 10^{-2}$						
Location 9	37.761, 38.266	269.8	0.7157	0.1931	121.6	0.3225	$3.92 x 10^{-2}$						
Location 10	37.762, 38.268	184.7	0.4899	$9.05 x 10^{-2}$	144.5	0.3833	$5.54 x 10^{-2}$						
Location 11	37.763, 38.271	250.8	0.6653	0.1668	144.2	0.3825	$5.52 x 10^{-2}$						
Location 12	37.763, 38.274	165	0.4377	$7.22 x 10^{-2}$	177.5	0.4708	$8.36 x 10^{-2}$						
Location 13	37.764, 38.277	272.1	0.7218	0.1964	279.3	0.7408	0.2069						
Location 14	37.764, 38.279	147.3	0.3907	$5.76 x 10^{-2}$	349.9	0.9281	0.3247						
Location 15	37.764, 38.282	81.23	0.2155	$1.75 x 10^{-2}$	134	0.3554	$4.76 x 10^{-2}$						
Location 16	37.763, 38.285	174.1	0.4618	$8.04 x 10^{-2}$	207.7	0.5509	0.1144						
Location 17	37.763, 38.288	257.7	0.6836	0.1762	229.8	0.6095	0.1401						
Location 18	37.763, 38.291	126.4	0.3353	$4.24 x 10^{-2}$	82.45	0.2187	$1.8 x 10^{-2}$						
Location 19	37.763, 38.294	137.1	0.3637	$4.99 x 10^{-2}$	72.6	0.1926	$1.4 x 10^{-2}$						
Location 20	37.760, 38.296	120.8	0.3204	$3.87 x 10^{-2}$	186	0.4934	$9.18 x 10^{-2}$						
Location21	37.763, 38.299	172.3	0.4570	$7.87 x 10^{-2}$	334.9	0.8883	0.2975						
Location22	37.764, 38.302	281.1	0.7456	0.2096	287.3	0.7621	0.2189						
Location 23	37.765, 38.304	46.04	0.1221	$5.6 x 10^{-3}$	120.5	0.3196	$3.85 x 10^{-2}$						
Location 24	37.766, 38.307	85.72	0.2274	$1.95 x 10^{-2}$	85.72	0.2274	$1.95 x 10^{-2}$						

As seen from Figure 3-5, the values of electric field strength, magnetic field strength and equivalent plane wave power density at GSM 900 MHz downlink frequency in the morning hours at the preselected locations along the Atatürk Boulevard at 250 m intervals (2th, 3th, 6th, 10th, 11th, 12th, 15th, 16th, 19th, 20th, 21th and 23th locations) were found to be greater than the measured values at GSM 1800 MHz and GSM 2100MHz (UMTS) downlink frequencies. The values of electric field strength, magnetic field strength and equivalent plane wave power density in found measurements were made at GSM 1800 MHz downlink frequencies at 8th, 13th, and 24th locations are greater than that of measured values at GSM 900 MHz and GSM 2100MHz (UMTS) downlink frequencies. The values of electric field strength, magnetic field strength and equivalent plane wave power density measured at the 1st, 4th, 5th, 7th, 9th, 14th, 17th, 18th and 22th locations in GSM 2100MHz (UMTS) downlink frequency is bigger than those of measured values at GSM900 MHz and GSM1800 MHz downlink frequencies.

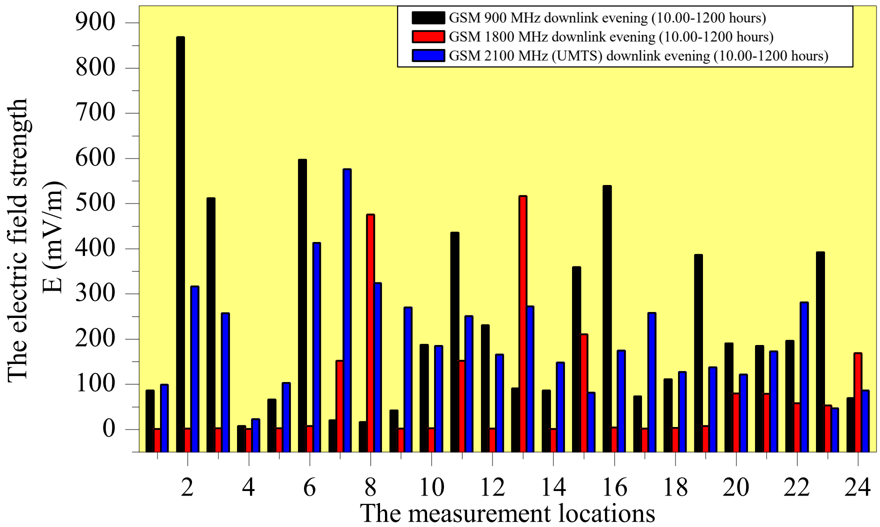

Figure 3. The comparison of electric field strength measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 10.00-12.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyzer.

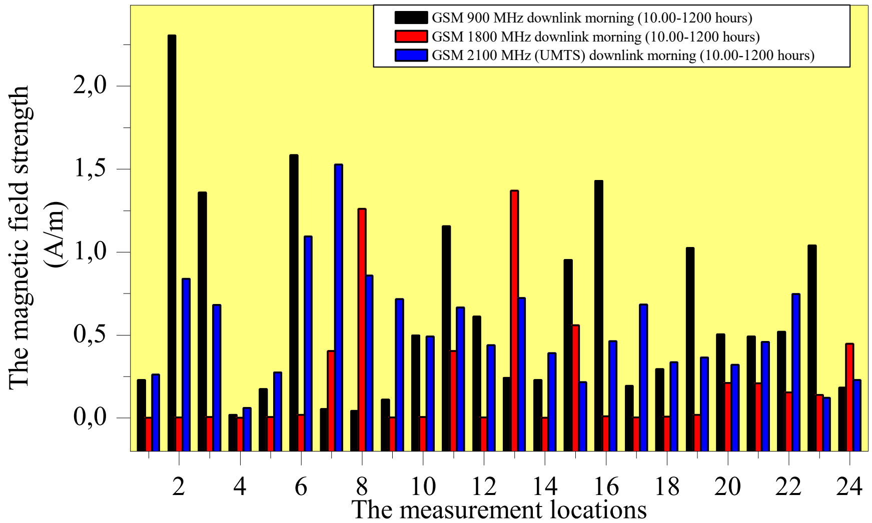

Figure 4. The comparison of magnetic field strength measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 10.00- 12.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyzer.

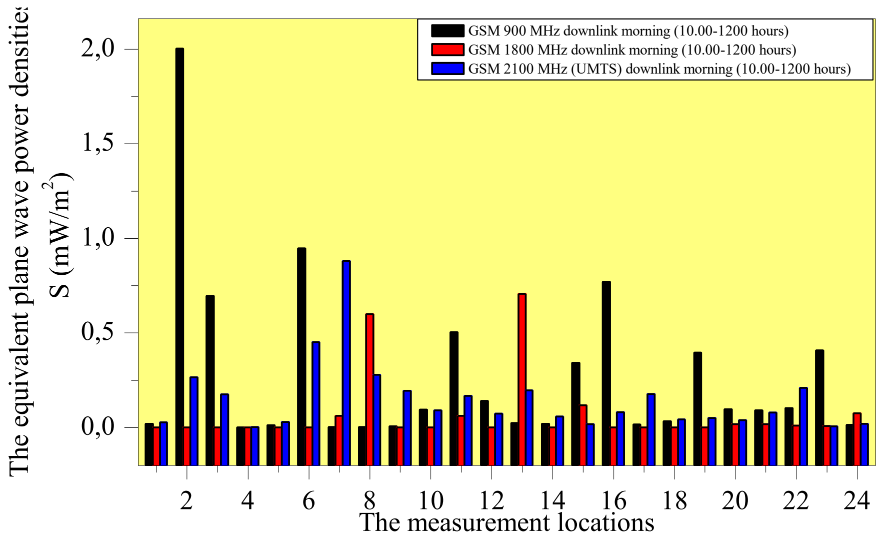

Figure 5. The comparison of equivalent plane wave power densities measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 10.00-12.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyzer.

However, as seen from Figure 6-8, the values of electric field strength, magnetic field strength and equivalent plane wave power density measured at GSM900 MHz downlink frequencies in the evening hours measured at 13 locations (1th, 3h, 4h, 7th, 10th, 11th, 13th, 16th, 18th, 19th, 20th, 23th, and 24th) were found to be greater than those of measured values at GSM1800 MHz and GSM2100 MHz (UMTS) downlink frequencies. Only at 5th location, the values of electric field strength, magnetic field strength and equivalent plane wave power density measured at GSM1800 MHz downlink frequencies were greater than those of measured values at GSM900 MHz and GSM2100 MHz (UMTS) downlink frequencies.

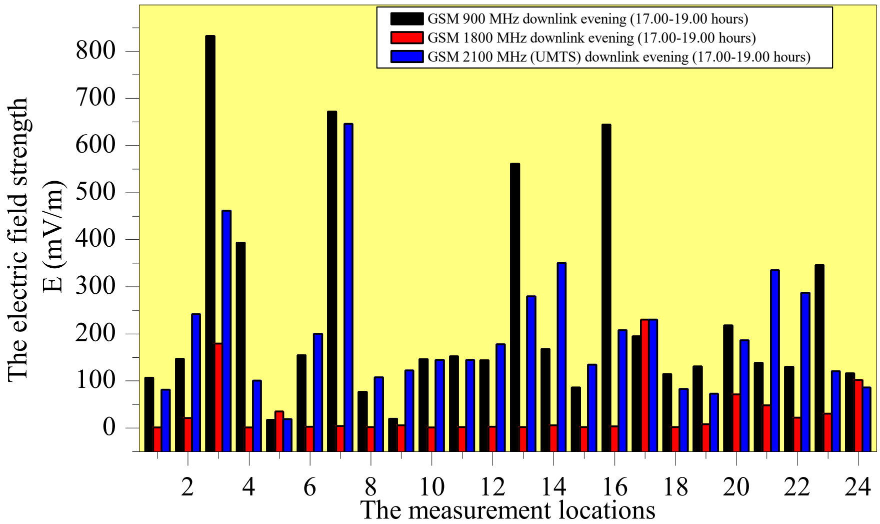

Figure 6. The comparison of electric field strength measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 17.00-19.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyzer.

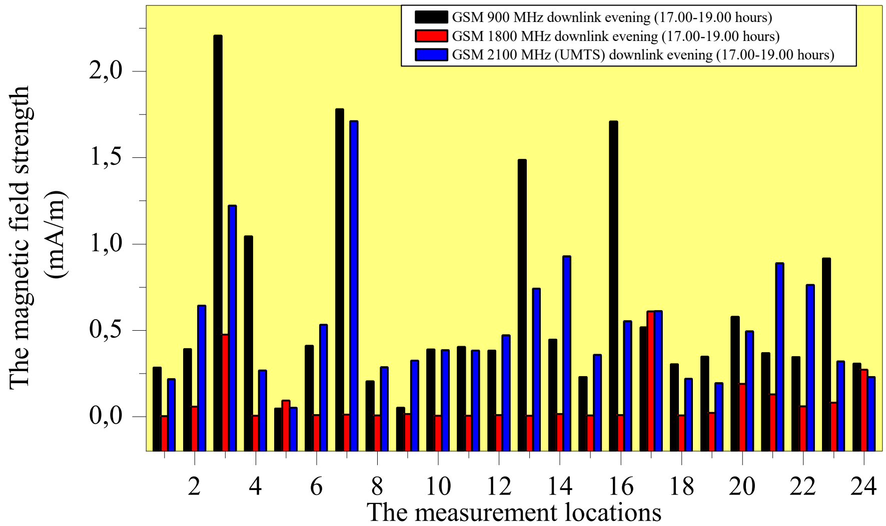

Figure 7. The comparison of magnetic field strength measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 17.00-19.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyzer.

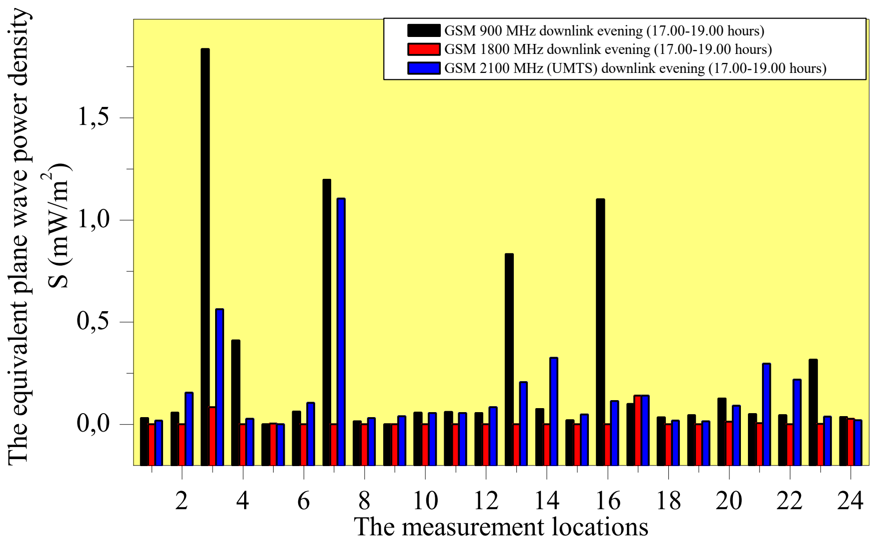

Figure 8. The comparison of equivalent plane wave power densities measured at GSM900 MHz and GSM1800 MHz downlink, and GSM2100 MHz (UMTS) frequencies between 17.00-19.00 hours by Aaronia Spectran HF-60105 V4 portable spectrum analyser.

As shown Figure 6-8, the values of electric field strength, magnetic field strength and equivalent plane wave power density measured at GSM2100 MHz (UMTS) downlink frequencies in the evening hours at 2th, 6th, 8th, 9th, 12th, 14th, 15th, 17th, 21th and 22th locations were greater than those of measured values at GSM900 MHz and GSM1800 MHz downlink frequencies. The reason for this may be due to the locations where the measurement values increase is closer to the base stations, increased number of the base station, and use of mobile phone and similar devices more intensive at times when measurements were performed. The reason for this having the values of the measurement smaller according to the other locations may be fewer number of the base stations in that locations or having the base stations far away from the measurement locations, and lower density of mobile phone and similar electronic devices when measurements were performed.

While the average value of the measurements of electric and magnetic field strength and equivalent plane wave power density between 10.00 and 12.00 hours at the GSM 900 MHz downlink frequency are 239.2339 mV/m, 0.6346 mA/m and 0.2799 mW/m^2, respectively, the values of measurements made between 17.00-19.00 hours are 237.58 mV/m, 0.6302 mA/m and 0.2734 mW/m^2, respectively. While the average value of the measurements of electric and magnetic field strength and equivalent plane wave power density between 10.00 and 12.00 hours at the GSM 1800 MHz downlink frequency are 82.392 mV/m, 0.2185 mA/m and 6.96x10^{-2} mW/m^2, respectively, the values of measurements made between 17.00-19.00 hours are 32.4863 mV/m, 8.62x10^{-2} mA/m and 1.17x10^{-2} mW/m^2, respectively. While the average value of the measurements of electric and magnetic field strength and equivalent plane wave power density between 10.00 and 12.00 hours at the GSM2100 (UMTS) frequency are 203.39 mV/m, 0.5395 and 0.15 mW/m^2 , respectively, the values of measurements made between 17.00-19.00 hours are 200.580 mV/m, 0.532 mA/m and 0.157 mW/m^2, respectively. The increase in the number of mobile phones and users as a result of development of science and technology has increased the amount of the radiofrequency origin non-ionizing radiation in our everyday life (RF; 10 kHz-300 GHz).

Consequently, GSM900 MHz, GSM 1800 MHz and UMTS 2100 MHz (UMTS) download link measurements were made throughout Atatürk Avenue. All of the E, H and S values found in the measurements were found to be much smaller than the limit values defined by BTK [15], ICNIRP [14] and IEEE/FCC [10, 13]. However, the E, H and S values determined at the measurement locations were varied from according to from a location to the next. The reason for this may be the mobile phones and similar communication devices are used or not used extensively at the time of measurement, the base stations are near or far away from the measurement locations, or that the numbers are more or less the same. The mobile phones and cell phone towers (base stations) are one of the most important sources of electromagnetic pollution in living areas. Accordingly, although the measured E, H and S values (electromagnetic pollution) are smaller than the limit values defined by national and international institutions and organizations, it is also important the duration of exposure as well as the intensity of exposure to radiation. For this reason, relevant institutions or organizations should investigate to reduce electromagnetic pollution, and in addition, conduct activities to increase community awareness of electromagnetic pollution.

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