Determination and Analysis of Electromagnetic Pollution at Two Shopping Malls in Konya at 100 kHz-3 GHz Frequency

Derya Gürğan and Levent Seyfi

***Abstract*— In this paper, short time electromagnetic radiation measurements were carried out at 100kHz-3 GHz frequency band to show electromagnetic pollution level at two shopping malls in Konya city centre. Measurements were performed at predetermined points on floor plans of shopping malls. Narda EMR-300 radiation meter was used as a measurement device and 6 minutes averaged values of measurement data were recorded. When the measurement results were examined, it was shown that limit values determined by ICTA (Information and Communication Technologies Authority) and ICNIRP (International Commission on Non-Ionizing Radiation Protection) were not exceeded by the measured electromagnetic radiation values and major electromagnetic radiation resource was signal boosting devices used for mobile phones.**

***Index Terms*—Electromagnetic pollution, GSM signal amplifier, non-ionizing radiation, radiation measurement.**

I. Introduction

Today, most people are very interested in technology. Cell phones that have been widely used in recent years and base stations that are increasing in number are the best examples. Of course, examples are not limited to the field of communication. Many electrical appliances, devices used in medical applications in hospitals, spots in shopping malls, advertising panels, which make life easier and which we use for our daily needs in our home (television, computer, vacuum cleaner, microwave oven, hair dryer etc.) are important examples. Developing technology has harms as well as benefits. It is known that every electrical device generates an electric and/or magnetic field around it. Electronic devices and also human body within this field may be affected negatively. The human body has a neural network that conducts electrical current, with an average length of 50,000 km and about 25 billion neurons. information is transmitted, stored, activated and reacted between organs via this system. This electric system has its own electromagnetic structure. Therefore, it can not be neglected that this system can be positively or negatively affected from external electromagnetic fields [1].

Whether the power of electromagnetic waves generated from electronic devices is high or low, these waves are subject to be effective on the human body. Electromagnetic waves may damage the tissues of the body by heating, or by causing chemical changes [2]. Increasing awareness of people day by day has boosted sensitivity to the concept of electromagnetic radiation. For instance, objections of neighborhood residents who made base stations near their houses take place in the news.

Electromagnetic radiation can not be perceived by sensory organs but can only be evaluated by a measurement device. For this reason, it has become important to measure, evaluate and investigate the effects of electromagnetic radiation on human health [3]-[8].

Within the scope of this study, it was aimed to measure and evaluate the electromagnetic radiation levels in two shopping malls located in the center of Konya because shopping malls are mostly used for shopping needs and also both social and cultural needs.

II. Material and Methods

In this study, measurements were made in order to determine the radiation levels that people are exposed to in shopping centers, where they often go with the family to meet both their needs and their fun. For the measurement, two shopping malls located in the center of Konya were determined and the measurements were made at the locations of the shopping centers marked on the floor plans which are shown in Fig.1 and 2.

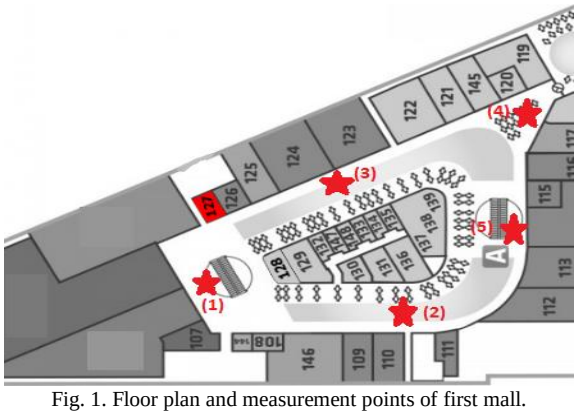

Fig. 1. Floor plan and measurement points of first mall.

Measurements were performed using the Narda EMR-300 instrument and electric field probe shown in Fig. 3. When the electric field probe is connected to the EMR-300 device, it measures in the frequency band of 100 kHz-3 GHz. During the measurement, the average of the 6-minute measurements using "AVRG" mode of the device was recorded in V / m.

All the measurements were evaluated in accordance with

Manuscript received April 27, 2018; revised July 2, 2018.

The authors are with Selcuk University, Faculty of Engineering, Dept. of Electrical and Electronics Engineering, Konya, Turkey (e-mail: eemderyagurgan@hotmail.com, leventseyfi@selcuk.edu.tr).

doi: 10.18178/ijesd.2018.9.9.1111

the limits determined by ICNIRP and ICTA [9], [10]. National limits determined by ICTA were updated in April 17, 2018.

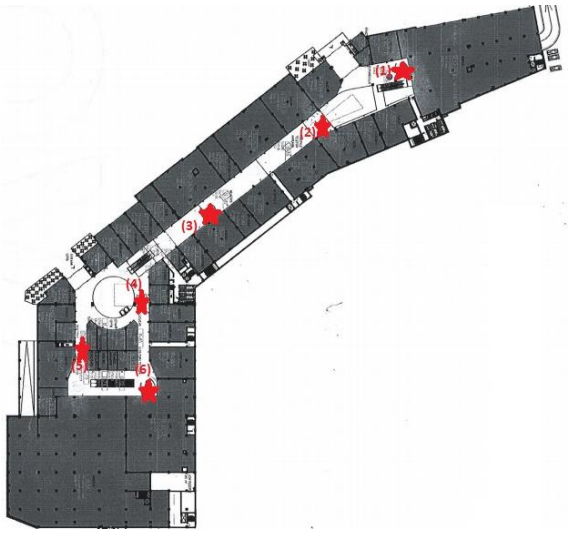

Fig. 2. Floor plan and measurement points of second mall.

Fig. 3. Narda EMR-300 radiation meter and E field prob.

III. Limit Values for Electromagnetic Radiation

Limit levels of time-varying electric fields determined for general public by ICNIRP are given in Table I. Although this values were accepted by most countries, some countries have organized new limit values which are unique and less than those of ICNIRP.

TABLE I: Limit Levels for General Public Exposure to Time Varying Electric Fields Determined by ICNIRP [9]

Frequency range, f	Electric field strength (V/ m)
up to 1 Hz	—
1–8 Hz	10,000
8–25 Hz	10,000
0.025–0.8 kHz	250/*f*
0.8–3 kHz	250/*f*
3–150 kHz	87
0.15–1 MHz	87
1–10 MHz	$87/f^{1/2}$
10–400 MHz	28
400–2,000 MHz	$1.375f^{1/2}$
2–300 GHz	61

In Turkey, A regulation protecting health of general public due to adverse effect of non-ionizing EM radiation, as shown in Table II, was organized by the Ministry of Environment and Urbanization in 2010. The limit values of time varying electric field strength are given in V/m for general public exposure here. When the limit values given in Table 1 and in Table II are compared especially at the frequency band including GSM operating frequencies (400 MHz-2000 MHz), it is seen that they are same. There is only one different limit value at 0.025 kHz-0.8 kHz frequency band between Table I and Table II. In this frequency band, national limit value is determined with the formula of 750/f which is three times of the limit value of ICNIRP (250/f).

TABLE II: Limit Values Protecting Health of General Public due to Adverse Effect of Non-Ionizing EM Radiation, Organized by the Ministry of Environment and Urbanization in Turkey in 2010 [11]

Frequency range, f	Electric field strength E(V/m)
Up to 1 Hz	-
1 Hz-8 Hz	10 000
8 Hz-25 Hz	10 000
0.025 kHz-0.8 kHz	750/f
0.8 kHz-3 kHz	250/f
3 kHz- 150 kHz	87
0.15 MHz- 1 MHz	87
1 MHz- 10 MHz	$87/f^{0.5}$
10 MHz-400 MHz	28
400 MHz-2000 MHz	$1.375f^{0.5}$
2 GHz-300 GHz	61

TABLE III: Determination of Limit Values of EM Radiation Originated from Electronic Communication Devices by Information and Communication Technologies Authority of Turkey In 2015 [12]

Frequency range, f (MHz)	Electric field strength (V/m)
0.01-0.15	65.25
0.15- 1	65.25
1- 10	$65.25/f^{0.5}$
10-400	21
400-2000	$1.03f^{0.5}$
2000-60000	45.75

In 2015, A revision on the limit values at frequencies from 10kHz to 60 GHz, as shown in Table III, was carried out by Information and Communication Technologies Authority of TURKEY. The limit values of time varying electric field strength are again given in V/m for general public exposure here. The limit values were decreased compared to the values given in Table II. At 0.01 MHz – 0.15 MHz frequency band, it was decreased from 87 V/m to 65.25 V/m. At 0.15 MHz – 1 MHz frequency band, it was decreased again from 87 V/m to 65.25 V/m. At 1 MHz-10 MHz frequency band, it was decreased from $87/f^{0.5}$ to $65.25/f^{0.5}$. At 10 MHz – 400 MHz frequency band, it was decreased from 28 V/m to 21 V/m. At 400 MHz – 2000 MHz frequency band, it was decreased from $1.375\ f^{0.5}$ to $1.03\ f^{0.5}$. At 2000 MHz – 60000 MHz frequency band, it was decreased from 61 V/m to 45.75 V/m.

In 2018, A new revision on the limit values at frequencies from 10kHz to 94 GHz, as shown in Table IV, was carried out by Information and Communication Technologies Authority of TURKEY. The limit values of time varying electric field strength are again given in V/m for general public exposure

here. The limit value at 790 MHz – 94000 MHz frequency band was decreased compared to the values given in Table 3. At 790 MHz – 2000 MHz frequency band, it was decreased from 1.03 $f^{0.5}$ to 0.96 $f^{0.5}$. At 2000 MHz – 94000 MHz frequency band, it was decreased from 45.75 V/m to 42.93 V/m.

TABLE IV: REGULATION ON THE AMENDMENT OF THE REGULATION ON THE DETERMINATION, CONTROL AND SUPERVISION OF THE EXPOSURE LIMIT VALUES OF ELECTROMAGNETIC FIELD INTENSITY FROM ELECTRONIC COMMUNICATION DEVICES BY INFORMATION AND COMMUNICATION TECHNOLOGIES AUTHORITY OF TURKEY IN 2018 [10]

Frequency range, f (MHz)	**Electric field strength (V/m)**
0.01-0.15	65.25
0.15- 1	65.25
1- 10	$65.25/f^{0.5}$
10-400	21
400-789	$1.03f^{0.5}$
790-2000	$0.96f^{0.5}$
2000-94000	42.93

IV. MEASUREMENT RESULTS

In the first shopping mall, at five locations marked on the floor plan on the first and second floor in Fig. 1, measurements were made. However, on the basement and car parking floors, measurement places were limited due to architectural differences among floors of the mall. A photo of example measurement place in the first shopping mall is shown in Fig. 4. The measurement results obtained in firs shopping mall are given in Table V.

Measurements in second mall were made at marked six places on the ground floor, first and second floor shown in Fig. 2. Since the basement was small, measurements could be carried out at only two points. The measurement results are given in Table VI.

Fig. 4. Appearance of an example measurement place in first mall.

TABLE V: MEASUREMENT RESULTS OF ELECTROMAGNETIC FIELDS AT FIRST SHOPPING MALL IN V/M

	M1	M2	M3	M4	M5
Ground floor	0.35	0.42	0.39	0.54	0.67
First floor	0.34	0.47	0.25	0.64	0.48
Second floor	0.35	0.63	0.25	0.52	0.28
Basement floor	0.21	0.34	0.93	0.74	
Parking floor	0.49	0.57			

When the measurement results are examined, it is seen that the values recorded in second mall are higher than those in first mall. This situation may have been due to the presence of more signal amplifiers in the second mall as shown in Fig.5.

TABLE VI: MEASUREMENT RESULTS OF ELECTROMAGNETIC FIELDS AT SECOND SHOPPING MALL IN V/M

	M1	M2	M3	M4	M5	M6
Ground floor	0.70	0.86	0.82	2.02	1.54	1.47
First floor	0.71	1.23	1.94	0.56	0.40	0.49
Second floor	0.75	0.51	0.65	0.40	0.33	0.36
Basement floor	1.10	1.44				

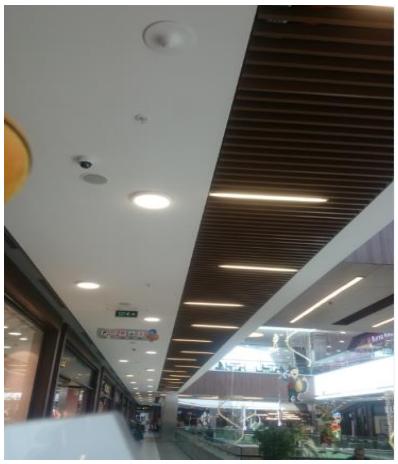

Fig. 5. Appearance of a measurement place in second mall.

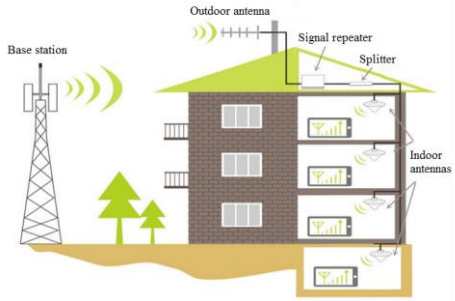

Fig. 6. Structure of GSM signal booster.

GSM signal amplifiers are used to provide uninterrupted communication in places where mobile phones are not receiving RF (Radio frequency) signal at enough level. They are basically like a base station. GSM signal amplifiers can operate in the 2G, 3G and 4.5 G frequency bands and can be effective in a closed area of about 500 m^2. As shown in Fig. 6, the signal received from the roof or from the external antenna installed at a high place is transmitted through a signal amplifier and then propagated into the building via an internal antenna. Thus, it is ensured that the mobile phones in the building are able to communicate successfully. When we looked around to find out the reason for the high values recorded during the measurements, we observed that these devices were used.

V. CONCLUSION

In this study, Narda EMR-300 EM measurement device was used to monitor electromagnetic pollution in predetermined two shopping malls located in the center of

Konya, Turkey. Varying electric field strength values were measured in average value mode at totally 41 different points in two shopping malls. When measurements are examined, the highest averaged value is observed as 2.02 V/m at M4 measuring point in the basement of second shopping mall. When two shopping malls are compared with each other, it is observed that measurement results are higher in second shopping mall. It is considered that this situation is originated from which more GSM signal amplifiers are used in second mall. It was determined that all electric field values obtained as a result of the measurements did not exceed the limits defined by ICTA (Information and Communication Technologies Authority of TURKEY) and ICNIRP (International Commission on Non-Ionizing Radiation Protection). The limits of electric field intensity determined by ICNIRP are 41.25 V/m for 900 MHz and 58.34 V/m for 1800 MHz [9]. In Turkey, ICTA updated the limits as 28.8 V/m for 900 MHz and 40.73 V/m for 1800 MHz [10]. These values are calculated by using the formula given in Table 4. The values obtained in the measurements vary from 0.21 V/m to 2.02 V/m. Although the measurement values do not exceed the limit values, the reporting of the measurements made in this study is important for the future. This situation can be easily understood from that the limit values have been lowered twice in 8 years (from 2010 to 2018) by ICTA.

REFERENCES

[1] A. Ö. Polat, "Obtaining the electromagnetic pollution map of Karaman city and Karamanoğlu Mehmetbey University Yunus Emre Campus," M.S. thesis, Mersin University, Mersin, Turkey, 2013

[2] F. Yağmur, A. Bozbıyık, and H. Hancı, "The effects of electromagnetic waves on human biochemistry," *TTB Continuing Medical Education Journal*, vol. 12, no. 8, pp. 296-297, 2003.

[3] N. M. Sarıkahya, "Evaluation of electromagnetic field measurement in a workplace and its results in terms of occupational health and safety," Expertise thesis, T.C. Ministry of Labor and Social Security, Ankara, 2014.

[4] L. Seyfi, "Measurement of electromagnetic radiation with respect to the hours and days of a week at 100kHz–3GHz frequency band in a Turkish dwelling," *Measurement*, vol. 46, no. 9, pp. 3002-3009, November 2013.

[5] L. Seyfi, "Determination of electromagnetic radiation levels at two primary schools near base stations," *International Journal of Electrical Energy (IJOEE)*, vol. 5, no. 1, pp. 49-53, June 2017.

[6] B. K. Engiz and Ç. Kurnaz, "Long-term electromagnetic field measurement and assessment for a shopping mall," *Radiation Protection Dosimetry*, vol. 175, no. 3, pp. 321-329, 2017.

[7] Ç. Kurnaz, B. K. Engiz, and M. C. Bozkurt, "Measurement and evaluation of electric field strength levels in primary and secondary schools in a pilot region," *Radiation Protection Dosimetry*, DOI: 10.1093/rpd/ncx275.

[8] İ. Seflek and E. Yaldiz, "Evaluation of electromagnetic pollution near Tv and radio broadcast transmitters," in *Proc. 8th International Advanced Technologies Symposium*, pp. 368-372, Elazıg, Turkey, Oct 19-22 2017.

[9] ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields," *International Council on Non-Ionizing Radiation (ICNIRP)*, Oberschleisseim, Germany, 1998.

[10] Information Technologies and Communications Authority (ICTA), "Regulation on the amendment of the regulation on the determination, control and supervision of the exposure limit values of electromagnetic field intensity from electronic communication devices by international standards," Official Gazette Issue: 30394, 17 April 2018.

[11] The Ministry of Environment and Urbanization in Turkey, "Limit values protecting health of general public due to adverse effect of non-ionizing EM radiation in 2010," 2018.

[12] Information Technologies and Communications Authority (ICTA), "Determination of limit values of EM radiation originated from electronic communication devices in 2015," April 2018.

Derya Gürğan was born in Konya, Turkey in 1988. She received the B.Sc. degree in electrical and electronics engineering from Selcuk University and she is MSc student at the same department now. Her research interests include radiation of base stations, and radiation of mobile phones.

Levent Seyfi was born in Kirsehir, Turkey in 1981. He received the B.Sc. degree in electrical and electronics Engineering from Gazi University and the M.Sc. and Ph.D. degree in Electrical and Electronics Engineering from Selcuk University in Turkey in 2002, 2006, and 2011, respectively.

From 2003 to 2012, he had been a research assistant at Dept. of Electrical and Electronics Eng., Sel çık University, Konya, Turkey. He was Asst. Prof. Dr. up to 2017 and has been Assoc.Prof.Dr. Since 2017 at the same department. His research interests include computational electromagnetics, ground penetrating radar, radiation of base stations, and radiation of mobile phones.