

Determination of Electromagnetic Radiation Levels at Two Primary Schools near Base Stations

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Abstract—In today's world, technological devices use for nearly every type of work is so much popular. These devices such as cellular phone, tablet, laptop, etc. facilitate and expedite our daily personal and technical works. Together with their advantages, disadvantages of them are also possible. Cellular phones work together with base stations mounted in residential areas while they are providing communication service to community. Base stations forward a call started from a cellular phone to the radio network controller. Then, the radio network controller forwards the call to another base station giving service to the called cellular phone. Cellular phones can communicate with base stations without a cable connection via radiation of electromagnetic (EM) waves. This type of EM radiation is called as non-ionizing radiation. As a result of researches carried out up to now, adverse health effect of radiation emitted from cellular phones and base stations is not certain. However, long term researches should be completed to show exact health effects of it on human health. In this context, till this topic is obvious and proved, we should be cautious about their radiation. Also, exposure levels of their radiation should be technically monitored periodically. This situation is of great importance for especially vulnerable groups of general public such as older, sick people, and kids. For these reasons, in this study, measured electromagnetic radiation levels at two primary schools near base stations in Konya, Turkey were recorded and analyzed according to the standard values determined by International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Information and Communication Technologies Authority (ICTA) in Turkey.

Index Terms—non-ionizing radiation, electromagnetic radiation, measurement, primary school, health

I. INTRODUCTION

In today's world, technological devices which are created for nearly every type of work is so much popular. Technological developments not only facilitate human lives but also bring some negative effects to our lives. These devices such as cellular phone, tablet, laptop, etc. facilitate and expedite our works. Together with their advantages, disadvantages of them are also possible. Due to electronic devices, and especially cellular phones, we are exposed to electromagnetic radiation.

Electromagnetic radiation originated from energy transmission lines, radio and TV transmitters emitting radio frequency waves, mobile phone base stations, transformers, and electronic home appliances in our life areas creates electromagnetic pollution [1]-[7]. Adverse effects of electromagnetic waves on human health may be possible [8], [9]. If electronic devices which increase life standard and are indispensable in modern life cannot be given up, solutions should be researched to control the possible negative effects of them. Cellular phones can work together with base stations mounted in residential areas. Radio network controller continues the call forwarded from the base station of the caller's cellular phone to another base station in the vicinity of the called cellular phone. Cellular phones can communicate with base stations without a cable connection via electromagnetic (EM) radiation. This type of EM radiation is a type of non-ionizing radiation.

EM waves can travel with a velocity of light ($c = 3 \times 10^8$ m/s) in space. Wavelength (λ) of EM waves can be found with a calculation of velocity/frequency. Thus, wavelength can vary in inverse proportion to frequency. Electromagnetic radiation can be classified in two groups according to its frequency, that is according to its wavelength, in respect of its effect on living being cells. Some applications expressed above create non-ionizing electromagnetic radiation. Electromagnetic waves being at high frequencies such as X-ray and Gamma-ray create ionizing electromagnetic radiation. These electromagnetic waves having very small wavelength behave as a photon and corrupt molecules in living being cell. These have enough energy in order to break atomic bonds and make cells positive or negative charged, that is, make it ionized. Thus, these corrupt bio-chemical structure of the body of any living being.

Even non-ionizing radiation does not have adverse effect like that of ionizing radiation; it might cause other biological effects. Of course these effects can vary according to the magnitude, exposure duration of electromagnetic radiation, and the properties of exposed living being. The closer a person is to an EM source, the higher magnitude of EM radiation exposes him/her. Because an ordinary person spends minimum their 8 hours in his/her office and 12 hours in his/her home; If EM source is so close to your office or home, both

parameters of magnitude and duration will increase. Additionally, because kids, old and sick people have weaker immune system, they are more vulnerable than an ordinary, healthy adult person.

Number of base stations has increased together with the increase of mobile phone used. Furthermore, mounting base stations everywhere in an uncontrolled way makes people who live in the vicinity of them anxious. Because they are more vulnerable to electromagnetic radiation than mature and healthy people, especially, the situations of the base stations mounted near babies, children, and sick people are of importance. Measurement studies on EM radiation can be carried out at more specific places as well as they were made across wide areas [1], [2], [5], [6], [10].

For these reasons, in this study, it is aimed to determine electromagnetic radiation levels in some primary schools which are next to base stations in Konya, Turkey. Additionally, the measurement results are compared with the standard values announced by the international commission on non-ionized radiation protection (ICNIRP).

II. MATERIAL AND METHOD

In this study, electromagnetic radiation values were measured with a radiation meter (Narda EMR-300) shown in Fig. 1. Measurement values were automatically 6 minutes averaged by the measurement device. The device can monitor total electric field value in a medium between the frequencies of 100 kHz and 3 GHz.

Measurements were executed in two different primary schools in Konya, Turkey selected due to being next to

base stations. First one is Ertugrul Gazi School whose coordinates are N 38.0027.88, E32.32.00.22. The school and the base station can be seen on the map in Fig. 2.

There is nearly 250 m between the school and the base station. The latter is Cemil Meric School whose coordinates are N34.00.44.66, E32.31.50.46. The map view of the school and the base station is shown in Fig. 3.

There is nearly 165 m between the school and the base station. The photos taken at Ertugrul Gazi and Cemil Meric School are shown in Fig. 4 and Fig. 5, respectively.

The distances are not very close to the schools but it should be noted that there are not any building or natural obstacle which can partially block directly radiated EM wave to the schools.



Figure 1. Narda EMR-300, electromagnetic radiation meter.

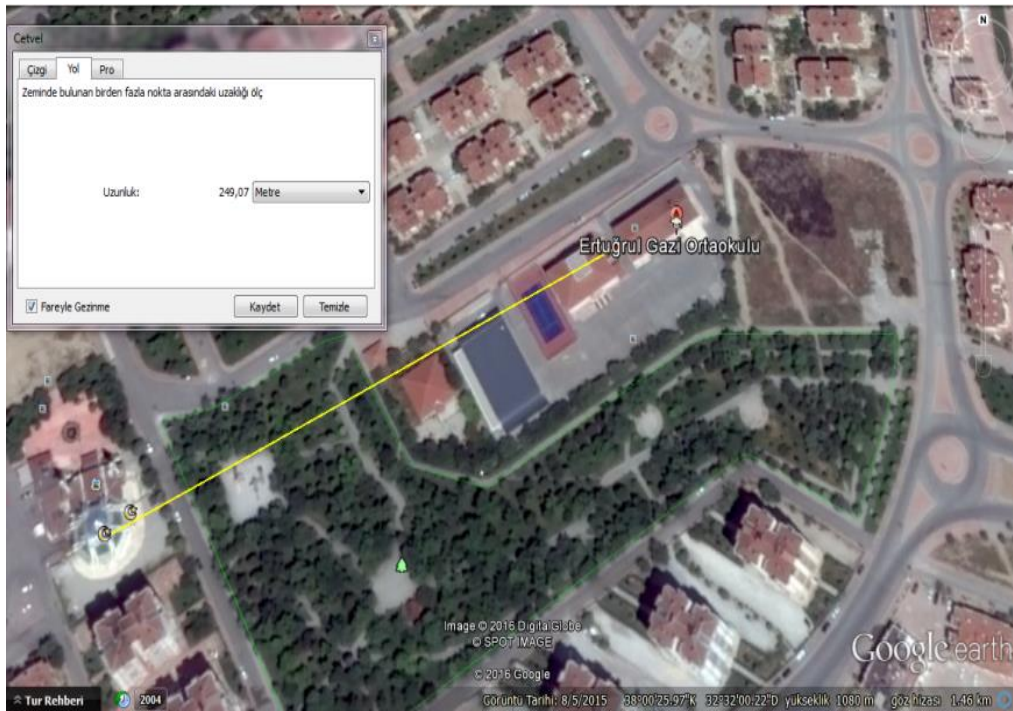


Figure 2. Map view of the Ertugrul Gazi School and the base station.



Figure 3. Map view of the Cemil Meric School and the base station.

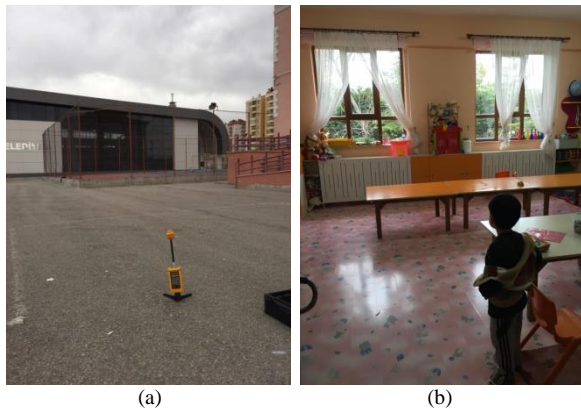


Figure 4. Some photos taken while electromagnetic radiation level was being measured in Ertugrul Gazi School.



Figure 5. Some photos taken while electromagnetic radiation level was being measured in Cemil Meric School.

III. MEASUREMENT RESULTS AND DISCUSSION

All the measurements were performed during 6 minutes. Thus, the recorded values were averaged Electric-field in V/m during 6 minutes. Measurement values recorded at Ertugrul Gazi School are given in Table I and at Cemil Meric School are given in Table II.

Measurements were repeated in corridor, class, courtyard, and teachers' room. Recorded values varied from 0.45 V/m to 0.97 V/m at Ertugrul Gazi School. Similarly, they varied from 1.20 V/m to 1.30 V/m at Cemil Meric School. These recorded values cannot be

considered as high when compared to national limit values determined in Turkey and international ones determined by ICNIRP. The national limit values are calculated as 30.9 V/m and 43.7 V/m for 900 MHz and 1800 MHz from Table III. The values given in Table III are updated data in 2015 by Information and Communication Technologies Authority (ICTA) in Turkey.

TABLE I. RECORDED ELECTROMAGNETIC FIELD VALUES AT ERTUGRUL GAZI SCHOOL

	Measured Electric Field (V/m)
Corridor (2nd Floor)	0.95
Class (3rd Floor)	0.97
Courtyard	0.95
Teachers' Room (2nd Floor)	0.71
Preschool (Entrance Floor)	0.45

TABLE II. RECORDED ELECTROMAGNETIC FIELD VALUES AT CEMIL MERIC SCHOOL

	Measured Electric Field (V/m)
Corridor (3rd Floor)	1.21
Class (3rd Floor)	1.26
Courtyard	1.20
Teachers' Room (2nd Floor)	1.30

The former limit values were same as the values determined by ICNIRP. Updated limit values are lower than international ones. The international limit values are

calculated as 41.25 V/m and 58.33 V/m for 900 MHz and 1800 MHz, respectively from Table IV.

Maximum radiation value measured at Ertugrul Gazi School is referred to 3.1% and 2.2 % of updated national limits for 900 MHz and 1800 MHz frequencies, respectively. Similarly, comparing maximum radiation value measured at Cemil Meric School with national limits results with 4.2% and 3 % for 900 MHz and 1800 MHz frequencies, respectively.

TABLE III. NATIONAL LIMIT VALUES DETERMINED IN TURKEY [11]

Frequency Range (MHz)	Electric Field Strength (V/m)	
	Limit values for only one device	Limit values of total radiation in a medium
0.010-0.15	19.3	65.25
0.15-1	19.3	65.25
1-10	$19.3f^{1/2}$	$65.25f^{1/2}$
10-400	6.2	21
400-2000	$0.305f^{1/2}$	$1.03f^{1/2}$
2000-60000	13.5	45.75

f: frekans (MHz)

Comparing the measurements with the ICNIRP limit values gives that it is referred to 2.4% and 1.7% at Ertugrul Gazi School for 900 MHz and 1800 MHz frequencies, respectively. Similarly, the rates are 3.2% and 2.2 % at Cemil Meric School for 900 MHz and 1800 MHz frequencies, respectively.

TABLE IV. INTERNATIONAL LIMIT VALUES DETERMINED BY ICNIRP [12]

Frequency Range	Electric Field Strength (V/m)
0-1 Hz	----
1-8 Hz	10000
8-25 Hz	10000
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	$87f^{1/2}$
10-400 MHz	28
400-2000 MHz	$1.375f^{1/2}$
2-300 GHz	61

IV. CONCLUSIONS

Electronic devices have been an important and inevitable part of our modern life. Especially, cellular phones has taken place in center of our life. But, electromagnetic radiation emitted by cellular phones and base stations worries people in respect of their health. Especially people whose home, office, and school are across a base station are really disturbed from this situation. In this context, independent researchers should play an important role by informing public about electromagnetic level of cellular phones and base stations. In this study, two school right next to base stations were determined in Konya, Turkey. Then, some measurement campaigns were designed to monitor electromagnetic radiation exposure of students originated from base stations mounted very near the schools. Measurements were carried out at different positions in the schools to represent the real situation. Measurement results show that electromagnetic radiation values varied from 0.45 V/m to 0.97 V/m at Ertugrul Gazi School and from 1.20 V/m to 1.30 V/m at Cemil Meric School. Maximum radiation value measured at Ertugrul Gazi School is referred to 2.4% and 1.7 % of international limits for 900 MHz and 1800 MHz frequencies, respectively. Similarly, comparing maximum radiation value measured at Cemil Meric School with international limits results with 3.2% and 2.2 % for 900 MHz and 1800 MHz frequencies, respectively. Evaluating these results shows that although the base stations were mounted right next to the schools, electromagnetic radiation values exposing students are equal to very small percent of the national and international limits for both 900 MHz and 1800 MHz.

Because kids are considered more vulnerable than a healthy adult people, schools are focused in this study. Similarly, these studies can also be extended for hospitals and homes for the aged. Even the measurement values are really low when compared to the national and international limit values, these type of studies are really important in respect of creating data record of exposed EM radiation.

REFERENCES

- [1] S. I. Henderson and M. J. Bangay, "Survey of RF exposure levels from mobile telephone base stations in Australia," *Bioelectromagnetics*, vol. 27, no. 1, pp. 73-76, 2006.
- [2] C. Bornkessel, M. Schubert, M. Wuschek, and P. Schmidt, "Determination of the general public exposure around GSM and UMTS base stations," *Radiat. Prot. Dosimetry*, vol. 124, no. 1, pp. 40-47, 2007.
- [3] 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.
- [4] T. G. Cooper, S. M. Mann, M. Khalid, and R. P. Blackwell, "Public exposure to radio waves near GSM microcell and picocell base stations," *J. Radiol.*, vol. 26, pp. 199-211, 2006.
- [5] A. Mousa, "Electromagnetic radiation measurements and safety issues of some cellular base stations in nablus," *Journal of Engineering Science and Technology Review*, vol. 4, no. 1, pp. 35-42, 2011.
- [6] O. Genç M. Bayrak, and E. Yaldız, "Analysis of the effects of GSM bands to the electromagnetic pollution in the RF spectrum," *Prog. Electromagn. Res. PIER* 101, pp. 17-32, 2010.

- [7] M. R. Usikalu and M. L. Akinyemi, "Analysis of radiation dose around some base stations in Ota and Lagos environ," *International Journal of Basic & Applied Sciences IJBAS-IJENS*, vol. 12, no. 05, pp. 7-13, 2012.
- [8] G. Maskarinec, J. Cooper, and I. Swygert, "Investigation of increased incidence in childhood leukemia near radio towers in Hawaii: Preliminary observations," *J. Environ. Pathol. Toxicol. Oncol.*, vol. 13, pp. 33-37, 1994.
- [9] B. B. Levitt and H. Lai, "Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays," *Environ. Rev.*, vol. 18, pp. 369-395, 2010.
- [10] B. K. Gül, Ç. Kurnaz, and B. K. Engiz, "Measurement and evaluation of electromagnetic pollution in Ondokuz Mayıs University Kurupelit Campus in Samsun," *International Journal of Advances in Electronics Engineering*, vol. 6, pp. 117-121, 2016.
- [11] [Online]. Available: <http://www.resmigazete.gov.tr/eskiler/2015/10/20151009-2.htm>
- [12] International Council on Non-Ionizing Radiation. (1998). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields. Oberschleisseim, Germany. [Online]. Available: www.icnirp.org/documents/emfdl.pdf



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