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.

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

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 I 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]

<table>
<thead>
<tr>
<th>Frequency range, f</th>
<th>Electric field strength E(V/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1 Hz</td>
<td>-</td>
</tr>
<tr>
<td>1 Hz-8 Hz</td>
<td>10 000</td>
</tr>
<tr>
<td>8 Hz-25 Hz</td>
<td>10 000</td>
</tr>
<tr>
<td>0.025 kHz-0.8 kHz</td>
<td>750/f</td>
</tr>
<tr>
<td>0.8 kHz-3 kHz</td>
<td>250/f</td>
</tr>
<tr>
<td>3 kHz-150 kHz</td>
<td>87</td>
</tr>
<tr>
<td>0.15 MHz-1 MHz</td>
<td>87</td>
</tr>
<tr>
<td>1 MHz-10 MHz</td>
<td>87/f^0.5</td>
</tr>
<tr>
<td>10 MHz-400 MHz</td>
<td>28</td>
</tr>
<tr>
<td>400 MHz-2000 MHz</td>
<td>1.375/f^0.5</td>
</tr>
<tr>
<td>2 GHz-300 GHz</td>
<td>61</td>
</tr>
</tbody>
</table>

In 2015, a revision on the limit values at frequencies from 10 kHz 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 10 kHz 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]

<table>
<thead>
<tr>
<th>Frequency range, $f$ (MHz)</th>
<th>Electric field strength (V/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01-0.15</td>
<td>65.25</td>
</tr>
<tr>
<td>0.15-1</td>
<td>65.25</td>
</tr>
<tr>
<td>1-10</td>
<td>$65.25f^{0.5}$</td>
</tr>
<tr>
<td>10-400</td>
<td>21</td>
</tr>
<tr>
<td>400-789</td>
<td>$1.03f^{0.5}$</td>
</tr>
<tr>
<td>790-2000</td>
<td>0.96$f^{0.5}$</td>
</tr>
<tr>
<td>2000-94000</td>
<td>42.93</td>
</tr>
</tbody>
</table>

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 first 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.

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**

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground floor</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>2.0</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>First floor</td>
<td>1.2</td>
<td>1.2</td>
<td>1.9</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Second floor</td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Basement floor</td>
<td>1.1</td>
<td>1.1</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| Parking floor  | 0.49| 0.57

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...
was born in Konya, Turkey in 1988. 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


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