ELECTROMAGNETIC FIELD DENSITY: EVALUATIONS ON SOME SPECIAL INSTRUMENTS USED IN BIOLOGY LABORATORIES

ELEKTROMANYETİK ALAN YOĞUNLUĞU: BİYOLOJİ LABORATUVARLARINDA KULLANILAN BAZI ÖZEL AYGITLARA İLİŞKİN DEĞERLENDİRMELER

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Abstract

As an electric field-magnetic field composition, only indirect inferences can be made about the effects of electromagnetic fields (EMA), which have been widely discussed in the axis of base stations-mobile phones. However there is no report and specific reports about biology laboratories where biologists workings with special instruments. The aim of the presented study is to contribute to the elimination of this deficiency to some extent. For this purpose, a total of thirty electrical and electronic devices used in different microbiological analysis and genetic research laboratories of Ege University Faculty of Science Biology Department, (one microbiology and two microbiological analyzes laboratory) were measured at different distances (1cm, 5cm and 50cm as working distance). According to the data, the density of EMA naturally decreases with increasing distance. It is interesting to note that unexpectedly high values are recorded for some instruments and also different values for instruments of different brands and models used for the same purpose. The general result is that the EMA concentrations generated by the devices under measurement are below the safety limits accepted in our country. However, if this perspective is broadened, it is reached the fact that biologists are exposed to more EMA for longer periods than people living and working in standard homes and offices. This is because there are electromagnetic interferences that cannot be measured in this research, which consist of many devices working simultaneously due to physical space shortages and environmental EMA sources. Moreover, some laboratory studies take too long. The mismatch of the parameters used in the EMA measurement in general, and the lack of a consensus on the health effects of EMA in particular, does not necessarily mean that there are no specific risks. Measures that can be taken in the extension of the cautious approach principle are also recorded in this framework..

Keywords: Electromagnetic field, Biology laboratories, Electronic devices.

Özet

Elektrik alanı-manyetik alan bileşimi olarak son yıllarda özellikle baz istasyonları-cep telefonları ekseninde geniş ölçüde tartışılan elektromanyetik alanların (EMA) biyoloji laboratuvarlarına özel aletlerle çalışan biyologlar üzerindeki etkilerine ilişkin olarak sadece dolaylı çıkarımlar yapılabilir, konuya dair özel bir rapora ulaşılamamıştır. Sunulan çalışmanın amacı bu eksikliğin bir ölçüde giderilmesine katkıda bulunabilmektir. Bu amaçla Ege Üniversitesi Fen Fakültesi Biyoloji Bölümünde bulunan bir mikrobiyoloji ile iki mikrobiyolojik analiz ve genetik araştırma laboratuvarında, farklı amaçlarla kullanılan toplam otuz elektrikli-elektronik cihazın, farklı mesafelerde (1cm, 5cm ve çalışma mesafesi olarak 50cm) oluşturdukları EMA yoğunlukları ölçülmüştür. Veriler göre EMA yoğunlukları mesafe arttıkça doğal olarak azalmaktadır. Bazı aletler için beklenmedik biçimde yüksek değerlerin, ayrıca aynı amaçla kullanılan farklı marka ve modeldeki aletler için de farklı değerlerin kaydedilmesi ilginçtir. Genel sonuç, ölçüm yapılan aygıtların oluşturduğu EMA yoğunluklarının ülkemizde kabul edilen güvenlik limitlerinin altında olduğudur. Ancak bu perspektif genişletilirse, biyologların, standart ev ve bürolarda yaşayan ve çalışan kişilere göre daha fazla EMA'ya daha uzun süreyle maruz kaldıkları gerçeğine ulaşılır. Çünkü hem fiziksel yer sıkıntısı nedeniyle aynı anda çalışan birçok aletten hem de çevresel EMA kaynaklarından (aydınlatmalar, sıva altı elektrik donanımları, araştırmacıların bilgisayar, tablet ve cep telefonu gibi kişisel elektrikli ve elektronik aygıtları, civardaki baz istasyonları…) oluşan ve bu araştırmada ölçülemeyen elektromanyetik girişimler söz konusudur. Üstelik bazı laboratuvar çalışmaları da çok uzun sürmektedir. Genel anlamda EMA ölçümünde kullanılan parametrelerin birbirleriyle uyumsuzluğu, özel anlamda da EMA'nın sağlık etkileri hakkında henüz bir konsensus sağlanamamış olması, hiçbir özel risk bulunmadığı anlamına kesinlikle gelmez. Temkinli yaklaşım ilkesi uzantısında alınabilecek önlemler de bu çerçevede kaydedilmiştir.

Anahtar Kelimeler: Elektromanyetik alan, Biyoloji laboratuvarları, Elekronik cihazlar.

1. INTRODUCTION

It is clear that with the great support of advances in rapidly developing imaging, microanalysis and information technologies, the branch of biology has reached the definition of "science of the age" from the definition of "half brother of physics". Today, biologists are involved in a wide variety of research studies, ranging from cloning to pesticide pollution, from gene mapping to conservation of species diversity, from drug research and development to environmental effects of microplastics. Biologists who have to work in different laboratories in this comprehensive task extension form a professional group that should be evaluated specially in terms of occupational health and safety practices, which have gained great importance in the world recently. As it is known, all research and education institutions, especially universities, and laboratories where biologists work in hospitals and other health institutions (imaging, biochemical and pathological analysis centers, etc.) carry special risks, especially chemical and radiation exposure.

Except for clinical studies, routine and / or new studies are regulated and controlled through a quality assurance system defined as good laboratory practices (GLP) from the planning stage to the reporting stage. The main objectives of this system are to protect human and environmental health, to ensure data quality and security, to keep test animal use to a minimum, and to save time and costs by preventing test and experiment repetitions. Regulations about the subject that mentioned above, have been performed by Turkey Ministry of Environment and declerated in 25.06.2002 dated, 24796 numbered national official gazzette in good laboratory practise regulations section. According to this section, "Devices used for control of environmental factors related to studies, data acquisition, storage and reuse, are properly placed, including computerized systems, and are planned to have sufficient capacity and design". Records of these activities are maintained. If possible, calibration would be such as to provide traceability with national and international measurement standards. " and the third article, "It is ensured that the devices and materials used in the study do not adversely affect the test system." as mentioned.

The fifth distinction of the regulation is titled "Test Systems". In this distinction, firstly, by mentioning the physical / chemical systems, "Devices used in obtaining physical and chemical data are properly placed, it is ensured to have sufficient capacity and appropriate design." expression is given. In the explanations about the biological test systems located just below, the details of the biological material are given and the devices are not mentioned in any way.

However, many and specific electrical and electronic devices are used during various studies in a modern biology laboratory. Employees are exposed to electromagnetic fields emitted from all these devices and equipment by work. In various heavy industry establishments, as well as in hospitals and medical centers, employees are considered to be in the special risk group using special equipment and devices and biomedical devices, and precautions are taken according to working conditions (TEMKODER, 2014, EXPONENT, 2017). However, in biology laboratories, data collection on EMA exposure of biologists working with special tools is almost nonexistent.

Electromagnetic fields are a combination of electric field and magnetic field with a very general definition. An EMF is also created almost everywhere where there is electricity and electric current. For example, when a device connected to an outlet and is operated, the electrical current passing through it creates an EMA in proportion to the power of the electrical source (WHO, 2018). While this area is the strongest next to the electrical device, the effect decreases to negligible levels as it moves away from the device, but it cannot be destroyed and reduced by external interventions.

As is known, the electric charge arises from the interactions of positively or negatively charged subatomic particles and, just like mass, is one of the structural properties of matter. The changes caused by electric charges in space around them create push-pull forces on other charges. Energy fields where electrical charge effects are observed are electrical fields or electric fields. The magnetic field, on the other hand, is a vector size that occurs not only between the magnet poles but also wherever moving electric charges, that is, the electric current. Its severity decreases with distance, just like in the electric field.

The electric wave and magnetic waves, which are oscillations perpendicular to each other in the direction of movement, (Polat, 2017), are displaced at the speed of electricity. When the electric field changes, the magnetic field changes, and the changed magnetic field changes the electric field. This chain process means the coincidence of two waves propagating in space perpendicular to each other (Figure 1.4). Electromagnetic oscillation is now considered a plane when the source is far enough away. EMA attributes are determined by their frequencies and wavelengths. The interactions of positively and negatively charged subatomic particles with EMA are related to their size (Çal, 2016).

It is a fact that personal and social awareness, anxiety and also scientific interest in EMA-human and environmental health relations are constantly increasing. When we look at the history of these relations, it is seen that the first reactions that resonated worldwide took place in the USA in 1977 against the 400 kV high voltage system planned to be established between Minnesota and North Dakota. As a result of this resistance, the interest of both researchers and management units has increased (Aktaş, 2016).

2. MATERIAL AND METHOD

2.1 Laboratory Selection

Three different microbiology, microbiological research and genetic research laboratories which have standart devices were choosen in Ege University Faculty of Science (EÜFF) Biology Department for EMF Measurements.

These laboratories are also used as offices. In these laboratories where work areas are located in the areas between the devices, some devices are also located on the desks of the researchers.

2.2 EMF Measurement

Measured devices are listed without listing the brands and models in particular, by giving the code number for use only in the related graphics, and those for the same purpose are grouped within themselves (Table 1).

Table 1. Measured devices and their intended use.

CODE NUMBER	DEVICE	INTENDED USE
1	CO_2 incubator	Providing constant temperature and humidity for tissue cultures growing in CO2 atmosphere.
2	Incubator -1	Cultivation, reproduction and characterization tests of microorganisms.
3	Incubator -2	
4	Incubator -3	
5	Incubator -4	
6	Incubator -5	
7	Incubating shaker -1	Even distribution of nutrients necessary for microorganisms throughout the culture medium.
8	Incubating shaker -2	
9	Spectrophotometer	Determination of different materials by spectroscopic analysis method
10	Gel electrophoresis	Nucleic acid-protein separation using horizontal gels.
11	HPLC	Analyzes such as purification and molecule separation in organic substances.
12	Analytical balance-1	High precision weighing of chemicals
13	Analytical balance-2	
14	Analytical balance-3	
15	Water bath	Keeping laboratory materials at a constant temperature.
16	Centrifuge-1	Separation of substances in the mixture according to their density.
17	Centrifuge -2	
18	Centrifuge -3	
19	Laboratory oven-1	Various heating, drying, sterilization processes, microorganism production at adjustable temperatures.
20	Laboratory oven -2	
21	Autoclave	Steam sterilization under high temperature and pressure.
22	PCR	Performing polymerase chain reaction
23	PCR	
24	pH meter	Measuring the ambient pH before and after the experiment.
25	Vortex	Making the solutions homogeneous by shaking them at a certain speed and time.
26	Climatization cabinet	Providing air conditioning with temperature, humidity and time parameters.
27	Block heater	Providing sensitive heating for various analytical procedures in different test containers.
28	Rotary evoparator	Evaporation and concentration of solvents.
29	Ice machine	It is used for making type ice cubes for laboratory use.
30	Power supply	Providing power and voltage output in case of power cuts.

2.3 Measurement Device

PCE-EMF 823 Electromagnetic Field Meter with EMF flux density measurements and some technical features are described below;

EMF range / resolution:

20 micro Tesla (µT) x 0.01 µT

200 µT x 0.1 µT

2000 µT x 1 µT

200 milli-Gauss (mG) x 0.1 mG

2000 mG x 1 mG

20000 mG x 10 mG

Number of axes: Single axis

EMF bandwidth: 30 Hz to 300 Hz

Sampling time: Approx. 1 second

Accuracy:

±4 % + 3 digits (up to 20 µT)

±5 % + 3 digits (up to 200 µT)

±10 % + 5 digits (up to 2000 µT)

2.4 Measurement Method

Since there is a working area in the regions between the devices, EMF can be exposed to both devices directly and during the device independent operation, from the front, right and left for each device; It is aimed to make a total of nine measurements from three different angles and three different distances: 1 cm, 5 cm and 50 cm.

However, due to the physical conditions of the laboratories, measurements could not be taken on the right and left sides for some devices located adjacent to each other and the wall. These devices are marked in the relevant tables.

The measurement distances are determined by using the values given by Türkkan and Pala (2009) and Sarıkahya (2014). It is obvious that the researcher will be at a distance of 1 and 5 cm to the devices while working in the laboratory, on / off, putting and receiving materials inside, passing through the device while working, ie only for short periods.

On the other hand, the normal working distance is 50 cm, where the researcher spends more time around the device, which can lead to EMA exposure for longer periods. has been accepted. The electromagnetic field meter was held 125 cm above the ground for at least 6 minutes and the measurements made while the devices were running were repeated twice a week. The averages of the minimum and maximum EMF values measured within six minutes are given in figures and charts with standard deviations. Measurements for the first five devices with the highest and lowest EMF intensity measured at a distance of 1 and 5 cm, all instruments were compared separately.

3. RESULTS

In the laboratories where measurements are made, the standard EMF intensity values and standard deviations created by the thirty different devices at 1 cm, 5 cm and 50 cm distance are given in Table 2. The overall conclusion made by evaluating the chart is that the density is related to the distance and decreases as expected from the device as expected. Evaluations based on this chart for each distance are recorded under separate subtitles.

Table 2. EMF intensity mean values and standart deviations (SD) of the different laboratory devices measured different distances (*measurements could not be taken from the right and left sides).

	EMF INTENSITY (mG)					
MEASUREMENT DISTANCE	**1 cm**		**5 cm**		**50 cm**	
CODE NUMBER	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
1	10,68	±1,70	6,02	±1,46	2,18	±0,75
2	2,76	±1,43	0,83	±0,18	0,52	±0,23
3	5,60	±2,07	0,32	±0,09	0,21	±0,06
4	29,98	±2,25	12,31	±1,09	2,25	±0,36
5	1,81	±0,44	0,91	±0,22	0,88	±0,19
6	2,47	±0,29	1,92	±0,98	1,23	±0,19

7	1,36	±0,46	0,67	±0,11	0,37	±0,05
8	6,95	±0,58	4,85	±0,48	0,38	±0,04
9*	0,55	±0,08	0,21	±0,04	0,15	±0,05
10	41,38	±1,81	26,42	±1,48	0,52	±0,05
11	3,08	±0,46	1,45	±0,31	0,21	±0,04
12	2,24	±1,63	1,76	±1,47	0,28	±0,13
13	1,57	±0,48	1,02	±0,40	0,43	±0,19
14	3,21	±0,12	0,97	±0,11	0,25	±0,08
15	15,06	±0,60	3,43	±0,48	1,39	±0,35
16	13,62	±0,74	3,22	±0,33	0,26	±0,06
17*	22,89	±8,96	5,48	±2,51	0,52	±0,17
18*	11,18	±0,72	1,66	±0,37	0,85	±0,22
19*	14,23	±2,11	10,09	±1,76	0,56	±0,21
20*	2,37	±0,20	0,52	±0,13	0,23	±0,08
21	5,70	±0,31	4,00	±0,23	0,81	±0,11
22	13,73	±6,31	2,15	±1,11	1,85	±0,23
23	8,12	±0,57	1,05	±0,27	1,1	±0,44
24	1,14	±0,12	0,85	±0,10	0,65	±0,08
25	739,81	±118,64	122,83	±33,24	13,86	±9,24
26	9,25	±1,12	0,49	±0,14	0,26	±0,07
27	42,81	±2,73	6,93	±0,56	0,31	±0,03
28	46,72	±1.25	19,73	±0,76	2,86	±0,19
29	3,75	±1,40	1,36	±0,42	0,66	±0,31
30	70,95	±2,55	55,94	±2,79	4,95	±0,46

3.1 EMF Intensity 1 cm from Device

In figure 1, data on EMA intensity measured at a distance of 1 cm from the device are given graphically.

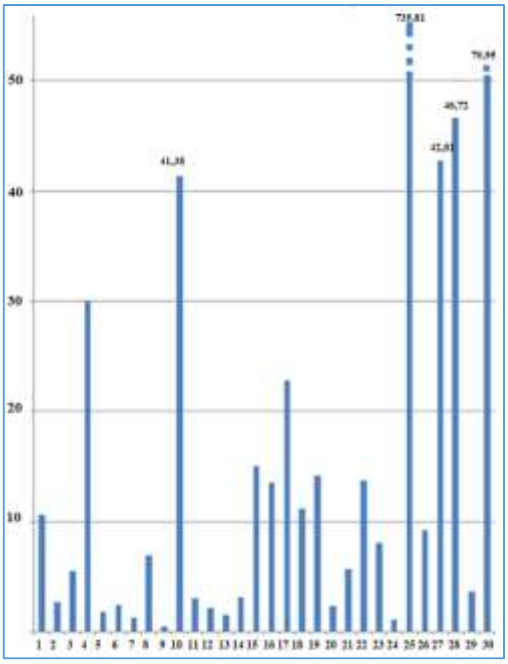

Figure 1. EMF measurements at a distance of 5 cm from the devices (mG).

The first five devices with the highest EMF intensity measured at this distance are vortex, power supply, rotary evaporator, block heater and gel electrophoresis device, respectively (Table 3). EMF density values in each of these devices at a distance of 1 cm are more than 40 mG. There is a huge difference between the vortex in the first row and the power supply in the second row.

Table 3. First five devices with highest EMF density measured at a distance of 1 cm.

CODE NUMBER	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
25	Vortex	739,81±118,64
30	Power supply	70,95±2,55
28	Rotary evoparator	46,72±1,25
27	Block heater	42,81±2,73
10	Gel electrophoresis	41,38±1,81

The lowest EMA intensity values at 1 cm distance to the device were measured in spectrophotometer, pH meter, incubator shaker-1, incubator-4 and incubator-5, respectively, as shown in Table 4.

Table 4. Five instruments with lowest EMA density measured at a distance of 1 cm (*measurements could not be taken from the right and left sides).

CODE NUMBER	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
9	Spectrophotometer*	0,55±0,08
24	pH meter	1,14±0,12
7	Incubating shaker -1	1,36±0,46
5	Incubator-4	1,81±0,44
6	Incubator-5	2,47±0,29

3.2. EMF Intensity 5 cm from Device

Data on EMA intensity measured at a distance of 5 cm from the device are presented graphically in Figure 2.

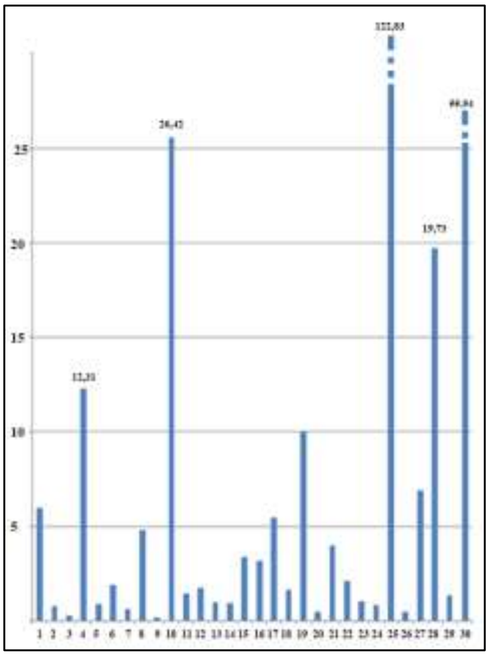

Figure 2. EMF measurements at a distance of 5 cm from the devices (mG).

According to the measurements at this distance, in the highest EMA values (Table 5), the first two rows did not change as the vortex and power source, but the values in these two tools decreased significantly compared to 1 cm distance.

Gel electrophoresis takes the third level. EMF severity values for all three instruments are higher than 25 mG. The next two devices are rotary evaporator and incubator-3, whose values are measured more than 10 mG.

Table 5. First five devices with highest EMF density measured at a distance of 5 cm

CODE NUMBER	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
25	Vortex	122,83±33,24
30	Power supply	55,94±2,79
10	Gel electrophoresis	26,42±1,48
28	Rotary evoparator	19,73±0,76
4	Incubator-3	12,31±1,09

At the lowest EMA values (Table 6) at this distance, the first place is followed by the spectrophotometer incubator-2 and oven-2. The last two rows are air-conditioning cabin and incubator-1.

Table 6. Five instruments with lowest EMA density measured at a distance of 5 cm (*measurements could not be taken from the right and left sides).

CODE NUMEBR	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
9	Spectrophotometer*	0,21±0,04
3	Incubator-2	0,32±0,09
20	Laboratory oven -2	0,52±0,23
26	Climatization cabinet	0,49±0,14
2	Incubator -1	0,83±0,18

3.3. EMF Intensity50 cm from Device

EMF intensity values, measured at this distance, which is accepted as normal working distance and all of which are below 14 mG, are given in Figure 3.

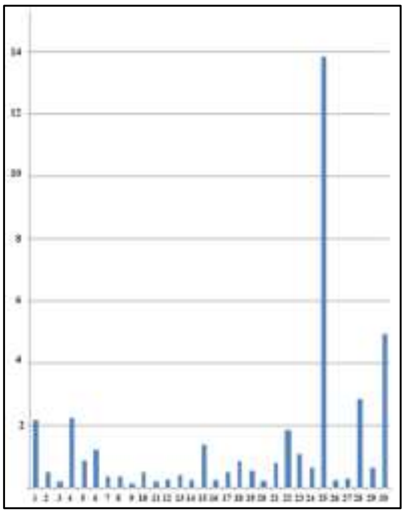

Figure 3. EMF measurements at a distance of 50 cm from the devices (mG).

Considering that the longest exposure will occur at this distance, it was preferred to give measurements of all devices instead of five, where only the highest and lowest EMA intensity values were measured at the working distance.

As in the closest distance, the highest values were measured in the vortex, power supply and rotary evaporator, respectively (Table 7). Of course, the values measured at this distance are lower for all instruments in the table than those measured at a distance of 1 and 5 cm.

Table 7. First five instruments with highest EMA intensity measured at operating distance (50 cm).

CODE NUMBER	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
25	Vortex	13,86±9,24
30	Power Supply	4,95±0,46
28	Rotary Evoparator	2,86±0,19
4	Incubator-3	2,25±0,36
1	CO_2 Incubator	2,18±0,75

The order after the first five devices, where the highest values are measured, is given in Table 8.

Table 8. EMA intensity values at the working distance (50 cm) of other devices (* measurements could not be taken from the right and left sides).

CODE NUMBER	DEVICE	MEASUREMENT VALUES (mean mG) ± SD
25	Vortex	13,86±9,24
30	Power supply	4,95±0,46
28	Rotary evoparator	2,86±0,19
4	Incubator-3	2,25±0,36
22	PCR-1	1,85±0,23
15	Water bath	1,39±0,35
6	Incubator-5	1,23±0,19
23	PCR-2	1,10 ±0,44
5	Incubator-4	0,88±0,19
18	Centrifuge-3*	0,85±0,22
21	Autoclave	0,81±0,11
29	Ice machine	0,66±0,31
24	pH meter	0,65±0,08
2	Incubator-1	0,52±0,23
19	Laboratory oven -1*	0,56±0,21
17	Centrifuge-2*	0,52±0,17
10	Gel electrophoresis	0,52±0,05
13	Analytical balance-2	0,43±0,19
8	Incubating shaker -2	0,38±0,04
7	Incubating shaker -1	0,37±0,05
27	Block heater	0,31±0,03
12	Analytical balance -1	0,28±0,13
26	Climatization cabinet *	0,26±0,07
16	Centrifuge-1	0,26±0,06
20	Laboratory oven -2*	0,23±0,08
3	Centrifuge -2	0,21±0,06
14	Analytical balance -3	0,25±0,08
11	HPLC	0,21±0,04
9	Spectrophotometer*	0,15±0,05

4. DISCUSSION

In this regard, it is necessary to make evaluations about the method first. Measurement distances were observed 3 cm, 30 cm and 1 m by Türkkan and Pala (2009); 1 cm, 10 cm, 30 cm and 1 m observed as Sarıkahya (2014). According to these studies our measurement distances were observed as 1 cm, 5 cm and 50 cm. Özen et al. (2014) did not give distances in the measurements made in the hospital central research laboratory, the distance was thought to be nearly 1-5 cm from the photos used in the study. EMA exposure at a distance of 1 m or even more in a laboratory environment is of course often possible, but it is not possible to work at a distance of 1 m to the instruments. It is ideal to have measuring ranges more frequent up to a distance of 1 m and even to measure beyond this distance, but due to the difficulty of the study, only three different distances have been taken.

Secondly, the measurements were taken during the working hours of the laboratories and during the normal working tempo. Ghazikhanlou-Sani et al. (2018), a different and more comprehensive method was used in the study to determine EMF density in Hamedan University Medical Faculty operating theaters. According to the devices 10, 20, 50 cm. and 1 m. EMF density of each tool at distances first, other devices are off and only the tool is working; while all tools and systems, including lights, are off; Finally, three different types of measurements were made during different surgeries.

This method is ideal in terms of determining the specific measurement values for each device first, and secondly, in determining the EMF intensity of different sources when all instruments and systems are closed, it also allows the comparison of EMF intensities of the different instruments used during different operations. The application of such a method in the presented study was not possible due to the fact that the closure of any device in the laboratories where many different researches are carried out at the same time is a serious problem. In this case, the advantage of the measurement method used in the study is that the measurements are real-time and real-state, since only one device will not work when performing operations in any laboratory (and no operating room). The disadvantages are that the location of the laboratories and the EMA values that may arise from the standard equipment (surrounding base stations, electrical-lighting installation, etc.) and the differences caused by the interference cannot be determined, and some instruments cannot be measured in all directions due to incompatibility of placement.

It should also be noted that the method applied by Çal (2016) considering the international and national standards is much more accurate. Unfortunately, it was not possible to apply such a method in this study, which was carried out with very limited possibilities only to achieve preliminary results.

The main result of the presented thesis is that when the EMA values at all distances are considered in general, the measured instruments do not exceed the 2000 mG limit. However, the limitations of the method and the importance of exposure time, as detailed below, should never be forgotten.

A study performed by NIEHS-NIH (EMF , 2002) was aimed to make comparison with some electrical-electronical devices used in daily life and measurements were recorded in mG (1μT = 10 mG). In this study where the EMF values decrease as the distance increases, the lowest and highest measurement ranges given for each distance are very wide, and the differences between the values measured at approximately the same distances (5 cm and 5.08 cm) for the same type of instruments are very striking. This is most likely due to the measurement of a large number of devices of different brands and models.

In our study, when the first five devices that produced the highest EMA at each distance measured were examined, it was seen that the first two rows did not change at all measurement distances as vortex and power source. The output power of the power supply (direct current) is recorded as 3000VA (= 3000W) and of course it is high. Indeed, Özen et al. (2014), the highest EMA intensity was measured as 3-5 μT (30-50 mG) on the "electrical panel room wall", but no comparison can be made since there is no information about this power center. Likewise, in a study conducted in a primary school in the USA (CPUC, 2016), EMF intensity in the electrical control room was measured as 1 μT (10 mG) in the classroom. EMF at 10 cm and 50 cm distance to the high voltage power supply used for operating theaters is the highest value measured among other instruments as 46.75 mG and 12.03 mG respectively (Ghazikhanlou-Sani et al., 2018). Eventually, EMA severity caused by power supplies is expected to be high.

However, it is an interesting finding that the vortex device whose output power is recorded as 60 W on its label is the highest source of EMF intensity at each distance. It is also noteworthy that there is a huge difference between the vortex device where the highest EMF density is measured at a distance of 1 cm and the second row power supply. The values are very variable in this device, as can be understood from the large deviation in the measurements recorded for the vortex (Table 6 amd 7). It is obvious that much more care should be taken in vortex use, especially in close proximity. Care should also be taken not to be located too close to the power supply for a long time.

As it is seen, EMA effects seem to be discussed for many years in terms of occupational health and safety, but the cautious approach expressed with the ALARA principle requires certain measures to be taken to prevent possible effects. In terms of occupational health and safety, there are many risks arising from the special working conditions of biologists. Among these, the least studied risk with little accumulation of data is EMF exposure in a laboratory setting.

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