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Research Article

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Human exposure assessment to electric and magnetic field emitted by mobile phones, television sets, and personal computers

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ABSTRACT

Development of technology has been caused that people expose to high level of electromagnetic fields (EMFs). The most important EMFs sources for public population are high pressure power line, radio, television, mobile phone, computer, tablet, and so on. Emitted electric and magnetic field can produce some human health impacts such as leukemia, cancer, brain disorders, and fertility problems. Therefore, EMFs have been became the subject of a large number of studies. The aim of this study is to investigate electric and magnetic field emitted by television (TV) sets, computer monitors and mobile phones in different distances and different conditions. Electric and magnetic field were measured by EMFs survey meter model HI 3603. The measured values were compared with ICNIRP public exposure limit and exposure levels were classified based on average intensity of the field (IF) method. The data analysis was conducted by SPSS 19 software. The electric and magnetic field emitted from mobile phones, TV sets, and LCD monitors in all distances and situation are lower than exposure limit. The exposure level class for TV set and mobile phone in different condition is low and for monitor in some vertical and horizontal distances is medium. There is need to public conduct essential protection against emitted EMFs by these devices. Also, electrical devices manufacturer should improve their production to reduce EMFs that emit from these systems.

Key words: exposure assessment, electric and magnetic, mobile phones, television, computers

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INTRODUCTION

The epidemiological and clinical studies show that EMFs can produce some potential adverse health effects on human health and other living organisms [1-3]. The childhood leukemia [4, 5], pregnancy and fertility disorders [1], female breast cancer, genotoxicity, brain tumors, and cancer [1, 6] are some EMFs adverse effects on human health. With regard to that central nervous system (CNS) is the most sensitive organ to EMFs [1, 7], therefore, EMFs maybe produce health problems such as amyotrophic lateral sclerosis, Alzheimer's disease, insomnia, headaches, sexual dysfunction, chronic fatigue, learning and memory problems, assorted other maladies [1] and sleep disorders [8, 9]. Also, EMFs have biological impacts on wildlife and other living organism. For example, DNA damaging has been observed in Eiseniafetida earth worm exposed with RF-EMF at the mobile phone frequency (900 MHz) [10]. Also, EMFs can create destructive effects such as perturbation in natural defenses, and reproduction disorders in rates, bates, and birds [11]

The extensive development and wide use of new technologies for lifestyle improvement and work efficiency enhancement have increased exposure to manmade electromagnetic fields (EMFs) during two recent decades [12-16]. The main artificial sources of the electromagnetic fields in environment are the wireless telecommunication technologies, electrical devices, home electronic appliances, electrical distribution network, electric power systems, and power lines [1, 4, 6]. In home and office EMFs mostly emit by electronic media such as mobile phone, television set, tablet, laptop, and personal computers. These devices are unavoidable part of today life and over the past two decades there has been a dramatic increase in using them [17-19]. For example, studies indicate that mobile phone application by world's population changed from 12% in 1999 to about 76% in 2009 [20]. Also the mobile phone owner in United States (US) and United Kingdom (UK) are 91% and 94% adults respectively [21].And based on research were conducted in Austria, teenagers and adults watch TV about 156 and 151 min/day respectively [22].

However, a major problem with these kinds of devices is potential harmful effects on human health [23]. One of the major agents of health impacts is emitted EMFs from this devices. Recently, researchers have shown an increased interest on studies about EMFs emitted by electrical home appliances and their impacts on human life. An examples of such studies are measurement of EMFs, and related disorders [24], health impact [25-27], and behavioral impacts [20, 22, 28], style and time of use [21, 29], and TV viewing and nutrition patterns [30]. So far, however, there has been little literature about exposure assessment of human to EMFs emitted from mobile phones, television sets, and computers. There is need to determine human exposure assessment to EMFs emitted from these devices. Because, exposure assessment is the most important step in guideline setting for EMFs, judgment about risk level of various devices, and recommendations about their using patterns.

This paper will focus on following topics because of major public health problems and likely risk from EMFs produced by phones, televisions, and desktop computers;

1) The measurement of EMF which are produced from phones, TV sets, and desktop computer
2) Public exposure assessment to EMF emitted with these devices
3) And comparison between measured levels of EMFs and national and international standards.

EXPERIMENTAL SECTION

EMF measurement and instrumentation

EMFs were measured by EMFs survey meter model HI 3603. Before measurement of EMFs, background EMFs were recorded. The different methods and conditions of use of mobile phones, TV sets, and monitors result in different directions relative field, reflection, and focusing, so different scenarios were chosen for measurement of emitted EMFs by these devices as follows. Firstly, the electric and magnetic field were measured separately in different horizontal distance (30, 50, 80, 100, 150, 200, 250, and 300 cm) from TV set. Because of accounting the most dangerous situation due to EMFs released from TV sets, TV with size 32 inch and more than 32 inch were selected that are most conventional TV set for home use.

Secondly, one of the most popular LCD monitors which is used in Iran were selected and emitted EMFs by these devices measured in different vertical (40, 20, 0, -20, and -40 cm) and horizontal (10, 20, 40, 50, 70, 90, and 110 cm) distances. To measure the electric and magnetic fields at various horizontal distances, straight in front of the user's eye was selected and for measurement EMFs in vertical distances, in front of user's eye was considered as zero height.

Finally, for measurement of the EMFs emitted from mobile phone, the horizontal distance from phone and ringtone situation were considered as effective factors. The EMFs were measured in different horizontal distances (10, 25, and 50 cm) and three ringtone situations (ringing, silent and vibrating).

Magnetic and electric field exposure classification

Electric and magnetic field were classified based on method that introduced by Havas Magda [31]. In this classification method, magnetic and electric field exposure is divided into four categories and each category is indicated by three symbols including code, color and ordinal name. The first class is low exposure and is specified by code 1 and green color. Second, third, and fourth classes (medium, high, and very high exposure) are indicated by codes 2, 3, and 4 and colors amber, red and black. This classification is dependent not only on electric and magnetic field level, but also on health impacts that are produced by them. For magnetic field, the magnetic flux density below 2, 2-10, 10-30, and more than 30 mG belong to low, medium, high and very high exposure classes, respectively. These levels were selected based on four more important health impacts that can be produced by exposure to magnetic field. The selection of four magnetic exposure levels from low to high are due to childhood

cancer, human breast cancer, spontaneous abortions and chromosomal aberrations respectively. The selected levels for electric field exposure categories are based on same logic as magnetic field exposure categories. These levels are below 5, 5-10, 10-30, and more than 30 v/m for low, medium, high and very high electric exposure levels, respectively. A health impacts related to the upper limits of the these ranges that were considered for selection base are starting biological impacts at electric field 5 v/m, calcium flux in chick brain at electric field 10 v/m, and increased risk of developing leukemia at electric field more than 30 v/m.

Statistical analyses

In this research for statistical analyses was used SPSS software (version-16). The Kruskal–Wallis analysis was used for comparison average of electric and magnetic fields at different vertical and horizontal distances and different ringtone situations ($P = 0.05$).

RESULTS AND DISCUSSION

TV sets

The results of electric and magnetic field emitted by TV sets were presented in figures 1 and 2. as shown in figure 2 The electric and magnetic fields exposure levels in all distances fall in to low class with code 1 and green color, but it is not means that condition is safe for public exposure and for more precise judgment we should consider determined exposure limits by regulatory national and international organization. Based on manufacturer information, TV set has frequency between 50 to 100 Hz. International Commission on Non-Ionizing Radiation Protection (ICNIRP) was defined 2.5-4 kv/m (based on frequency) and 200 mG as exposure limits to magnetic and electric field, respectively. Based on ICNIRP exposure limit which were defined for public exposure to electric and magnetic field, electric field and magnetic field in all distances are lower than permissible limit. TheKruskal–Wallis analysis results show that there is significant difference between average of electric and magnetic field at different vertical and horizontal distances ($P < 0.05$).

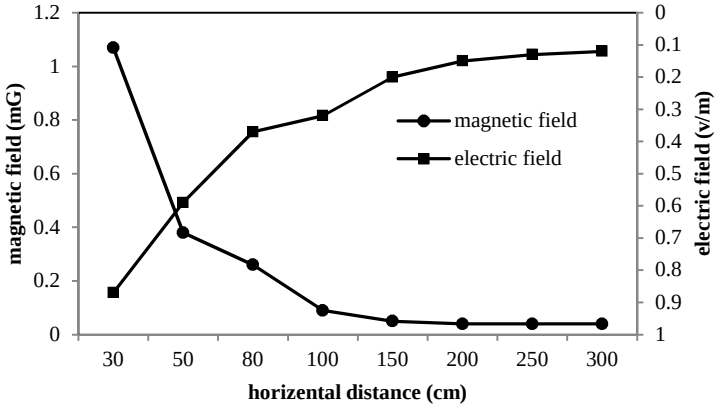

Figure 1: magnetic and electric field level emitted by TV in different horizontal distance

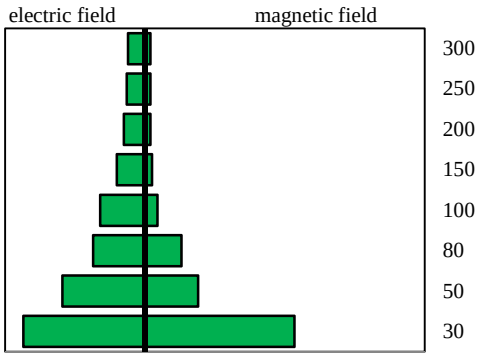

Figure 2: electric and magnetic exposure classification emitted by TV sets in different horizontal distances (numbers at right of figure)

LCD monitors

As shown in figure 3, electric and magnetic field decrease as horizontal distances from LCD moitor increase. TheKruskal–Wallisanalysis results show that there is significant difference between average of electric and magnetic field at different vertical and horizontal distances ($P< 0.05$). The measured electric and magnetic field in different vertical distances were presented in figure 4. The highest electric and magnetic field level relate to 0 distances.

Induced field in zero distances is more important than other distances, because maximum combination of the field to the exposed individual is happened and localized adsorption of field is high in this distance. For both magnetic and electric field measured level in distances above 0 cm is lower than measured level in distances below 0 cm. This may be due to computer case that was positioned in beneath computer desk.

In this study LCD monitor type of with 16 inch size and frequency between 30 to 80 kHz was used. For determination of general public exposure standard, 83 v/m and 270 mG were selected as exposure limits for electric and magnetic field, respectively. The measured electric and magnetic field in difference horizontal and vertical distances were compared with this limit and results show that electric field in all horizontal and vertical is lower higher than regulatory level. The results of the exposure level classification were shown in figure 5. Based on this figure, electric and magnetic field in all horizontal distances is grouped as low exposure class with code 1 and green color while electric field in distance 0 vertical and magnetic field in distances 0, -20, and -40 fall into second categories (medium exposure) that is indicated with code 1 and amber color.

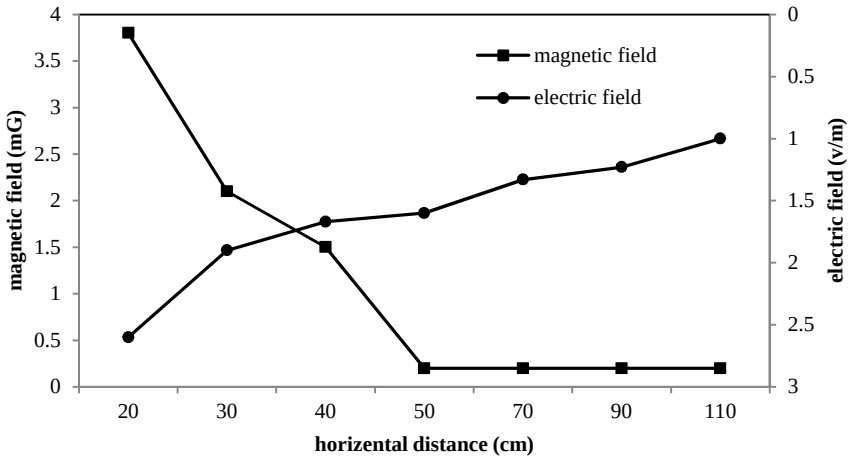

Figure 3: magnetic and electric field level emitted from LCD monitors in different horizontal distance

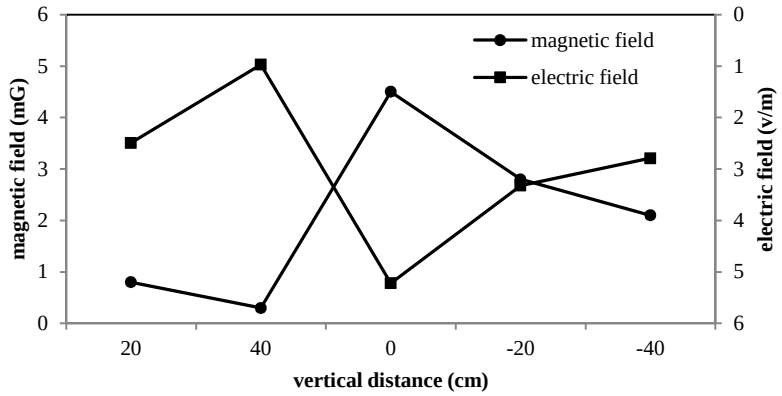

Figure 4: magnetic and electric field level emitted from LCD monitors in different vertical distance

Mobile phone

Figures 6 and 7 show results of electric and magnetic field emitted by mobile phone in different ringtone situations and different distances. The electric and magnetic field in distances 20 and 50 centimeter are negligible compared with 5 cm distance from mobile phone. The electric field in vibrating situation and magnetic field in ringing situation has highest values. The frequency of Iranian communication network is 900 and 1800 MHz. With regard to these frequencies, 1.38 and 1.95 mG and 41.25 and 58.3 v/m were selected as public exposure limits for magnetic and electric field respectively. The first level is for frequency 900 MHz and second level allocate to frequency 1800 MHz. As seen in figure 6 and 7, electric and magnetic field in all ringtone situation and all distances are less than permissible limits. Also electric field and magnetic field in all condition are categorized as low exposure level with code 1 and green color. On the basis of statistical analysis (table 1), there is significant difference between average of electric and magnetic fields at different horizontal distances for different situations ($P < 0.05$). Also, there is significant relation between average of electric and magnetic field at different ringtone situations.

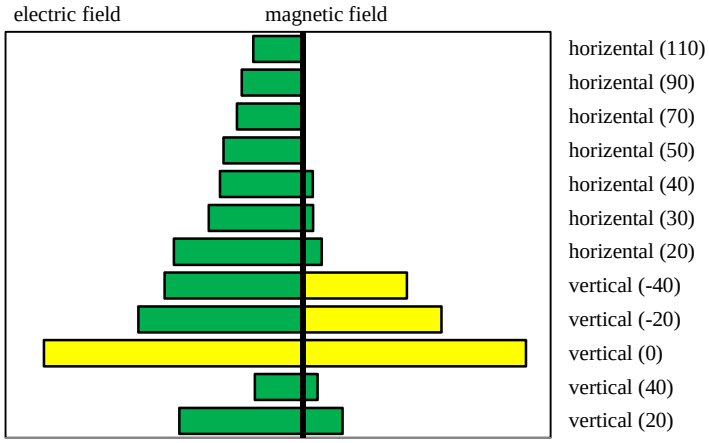

Figure 5: electric and magnetic exposure classifications from LCD monitor in different vertical and horizontal distances (were indicated at right of figure)

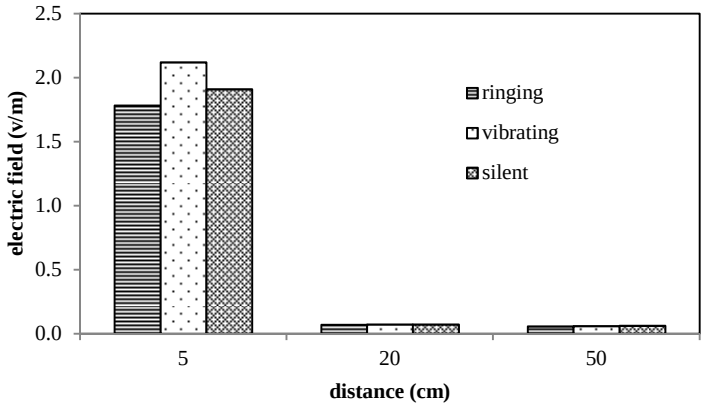

Figure 6: electric field level emitted from mobile phone in different ringtone situation

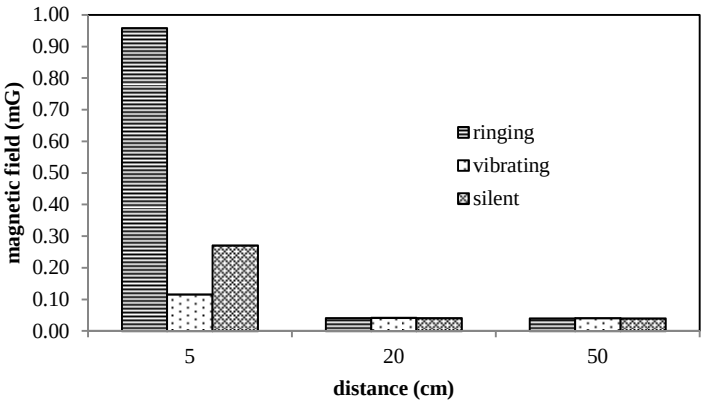

Figure 7: magnetic field level emitted from mobile phone in different ringtone situation

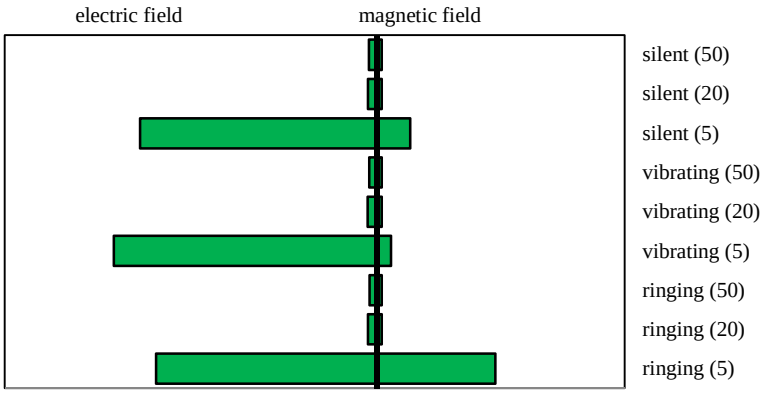

Figure 8: figure: electric and magnetic exposure classification due to mobile phone in different horizontal distances and different ringtone situation (indicated at right of figure)

Table 1: result of statistical analysis of electric and magnetic field emitted by phone at different situation and distances

Ringtone situation	Horizontal distance (cm)	Magnetic field		Electric field		Magnetic field		Electric field	
		mean	Sig.	mean	Sig.	mean	Sig.	mean	Sig.
ringing	5	0.96	<0.05	1.78	<0.05	0.35	<0.05	0.64	<0.05
	20	0.04		0.07					
	50	0.04		0.06					
vibrating	5	0.12	<0.05	2.12	<0.05	0.067		0.75	
	20	0.04		0.07					
	50	0.04		0.06					
silent	5	0.27	<0.05	1.91	<0.05	0.067		0.68	
	20	0.04		0.07					
	50	0.04		0.06					

CONCLUSION

The results show that electric and magnetic fields emitted from three devices in different distances and situation are not higher than regulatory standards. But it does not mean that these electronic systems are safe for consumers from the point of view electromagnetic fields. Firstly, these measurements were conducted in specific condition and when devices were on solely. Whereas, in normal condition People may be exposed to a variety of sources emitting electromagnetic fields. For example, in home sources such as light lamp, TV set, microwave oven, radio, computer may be on power that result in more strength electromagnetic field and more adsorbed dose by consumer. Secondly, in this research one or more specific system with specific features was evaluated. While, there are various types of this devices with different sizes, and performance systems and methods in community that can emit different levels of EMFs. For example, type, operating systems, and communication frequency are different in different areas and countries and can provide different condition from point of view EMFs. And thirdly, effects of EMFs exposure depend on environmental conditions such as temperature and personal characteristics such as age, and disease. So, different people have different sensitivity to EMFs and permissible limit is different for them. With regard to mentioned reasons, the manufacturer of electronic devices should improve their products to reduce emitted EMFs by these devices and provide information about EMFs for consumers. Also, consumer should consider danger level of devices in selection processes. The governments and regulatory organization should supervise on quality of products and provide condition for setting of EMFs standard.

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