Electromagnetic Pollution in the Computer Labs: The Effects on the Learning Environment

Yavuz Erdogan
University of Marmara, Turkey

Abstract

Electromagnetic fields (EMF) became increasingly a common constituent of the general and workplace environments early in the 20th century. The biological and physiological effects of EMF become a topic of considerable scientific researches during the past two decades. Also, some of scientists claim that EMF causes physiological stress, producing symptoms of tiredness and difficulty concentration. These symptoms could be able to affect the learning environment in negative way. Considering all these points, the purpose of this study is to investigate the effects of EMF on the learning environment of the computer laboratories. The EMF measurements were carried out in four different computer laboratories at Marmara University. To determine the magnitude of EMF in the computer laboratories, the exposure level tester ELT-400 was used. At the end, it was found that the EMF levels around the UPS devices displayed dangerous levels to health, and these results were above the exposure limits set by International Commission on Non-Ionizing Radiation Protection (ICNIRP).

Introduction

In recent years, the rapid development and increase in number, especially, of the devices that work under the theory of electromagnetic fields has put the electromagnetic pollution on the agenda as a new threat. Electromagnetic pollution, that is received through high-tension lines, mobile phones, radio/TV waves and the computers at home and at work, causes an unhealthy atmosphere in the social life (Kalkan et al, 1994, p.73; Sevgi, 2000, p.1). The National Regulatory Research Institute (NRRI), whose headquarters are in the USA, accepted the negative effects of electromagnetic fields on public health as one of the most serious environmental problems and declared that safeguard measures should be legalised (Atalay, 1999, p.1). During the last 20 years, research on the biological effects of the electromagnetic fields has increased rapidly and has attracted worldwide attention. So what, then, is an electromagnetic field?

The electric current creates electric and magnetic fields around the transmitter as it is passing through it. The combination of these fields, which intersect each other at 90° on their vectoral positions is called an electromagnetic field (Artun, 2006, p.2). The magnetic field is the space where active and electrically loaded particulars are exposed to power and is created as a result of the rotation of the electrons in the atom around the nucleus and around themselves. Electromagnetic field is a concept which cannot be seen with the naked eye, but can be seen or felt by its consequences (Bold, Toros and Şen, 2003, p.62). Exposure to low-frequency electric and magnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to a uniform (plane-wave) electromagnetic field results in a highly non-uniform deposition and distribution of energy within the body, which must be assessed by dosimetric measurement and calculation (ICNIRP Guidelines, 1997, p.497). Although how magnetic fields affect the human organisms has not been understood precisely, research has demonstrated that magnetic fields are more effective than electric fields. Electric fields cannot pass through the walls and their magnitude decrease

greatly even passing through the human skin. However, magnetic fields cannot be blocked except using specially produced materials.

Human beings are under the effects of both their own magnetic fields and the magnetic fields of the natural environment they live in. Although magnetic fields have benefits, they can be dangerous if unbalanced. Regarding the rules of biomagnetology, all substances, thus all living creatures possess a magnetic feature either weak or strong. There exist high or low magnetic fields in every single empty space, in every location, consequently inside and outside of all living creatures. In fact, the human body is an electromagnetic machine in which every cell has its own electric circuit (Bold, Toros and Şen, 2003, p.63). The human body produces free electric loads against the magnetic forces created by the currents passing through nearby energy transmission lines or electrical devices (Şeker ve Çerezci, 2000). This gives rise to humans being affected by the electromagnetic pollution. In many laboratory and epidemiologic studies until today, electromagnetic pollution has been stated to be harmful to human health (Chernoff et al, 1992, p.91; Brent et al, 1993, p.201; Shaw and Croen 1993; NAS 1996; Tenforde 1996).

In 1991 in the USA, in 1992 in Sweden and in 1993 in Mexico, relations were found between cancer in children and living nearby electric lines (Bold, Toros and Şen, 2003, p.62). The electromagnetic waves damage the immune system by blocking the signals send from the brain to the cells. In experimental research carried out with laboratory animals under different frequencies, energy levels and exposure periods, deterioration was observed on the nerve tissues (Eraslan et al, 2002, p.1244). What is more, in the studies concerning laboratory animals' learning various relations were also found (Sabuncu, 2002, p.16).

In 1974, the International Radiation Protection Association (IPRA) formed a working group on non-ionizing radiation (NIR), which examined the problems arising in the field of protection against the various types of NIR. At the eighth International Congress of the IRPA an independent scientific organization –the International Commission on Non-Ionizing Radiation Protection (ICNIRP) was established as a successor to the IRPA. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, developed international guidelines on NIR exposure limits, and deal with all aspects of NIR protection (ICNIRP Guidelines, 1997).

People are being exposed to electromagnetic fields under different circumstances within the social life. One of these circumstances is the computer laboratory in educational settings. The monitors, as well as the power suppliers (UPS) in the computer laboratories cause a considerable amount of electromagnetic pollution. The electromagnetic fields emitted especially by the monitors affect people. For instance, the electromagnetic fields emitted by the monitors were observed to decrease the level of melatonin and increase the level of Adrenocorticotropic Hormone (ACTH) in the body (Arnetz ve Berg, 1996, p.1108). Furthermore, it was reported that the electromagnetic fields emitted by the monitors caused the death of embryos in the experiments carried on chicken embryos (Youbicier-Simo, 1997, p.514). As a result, learning environments can be affected by the electromagnetic pollution. Figure-1 displays the emission of the magnetic fields from the computer (Şeker ve Çerezci, 2000).

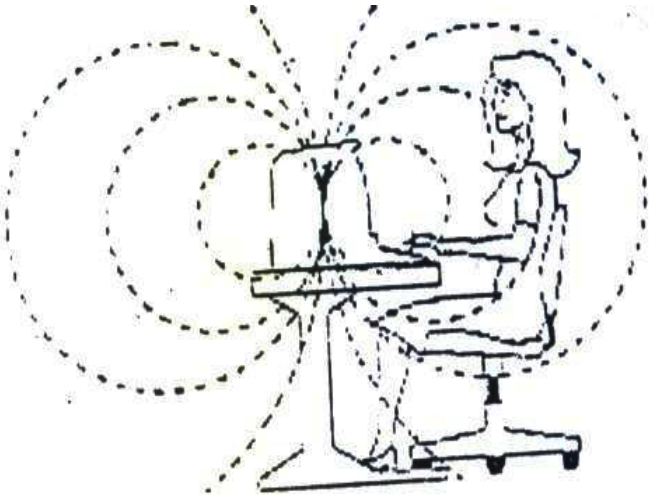

Figure 1. Emission of the magnetic fields from the computer

Accordingly, in the studies on laboratory animals' learning, various relations were observed (Sabuncu, 2002, p.16). Besides that, exposure to electromagnetic fields causes physiological stress, producing symptoms of tiredness, difficulty in concentrating and poor sleep (Mittelstaedt, 2006, p.3). Considering all these points, the current study hopes to investigate the effects of electromagnetic fields on the learning environment of the computer laboratories. With this aim in mind, the research questions to be investigated in the study are stated below;

- What are the EMF levels in the computer laboratory?
- Are these levels compatible with the international standards?
- How are the students affected by the electromagnetic pollution in the computer laboratory?

Methods and Procedures

The study consisted of two stages. First, the electromagnetic field levels in the computer laboratory were determined. The measurements were carried out in four different computer laboratories at Marmara University. The typical characteristics of the electrical equipment in each laboratory were as follows;

- 20 desktop computers (Pentium IV, 2.8 Ghz)
- 1 power supply (10 Kva, 50/60 Hz)
- 1 projection apparatus (110/230 V, 50/60 Hz)
- 20 monitors (15", 100/240V, 50/60 Hz)
- 20 speakers (500 Watt)

The measurements in four different laboratories were carried out by the measurement material detailed below. All other electrical equipment and mobile phones that are outside the limits of the research were removed from the laboratories for the measurements. All of the measurements were at 50 Hz frequency and in four different points of each laboratory. The results for each laboratory were analysed and interpreted individually. The results were then compared to the exposure limits set by ICNIRP and were interpreted accordingly.

Measurement Material

To determine the magnitude of electromagnetic fields in the computer laboratories, the exposure level tester ELT-400 was used. The ELT-400 is an innovative exposure level meter for measuring magnetic fields in the workplace and in public spaces. The model is designed for health and safety professionals in industry, the insurance business and the service industry. The instrument can handle practically any level measurement requested in the low and medium-frequency range, simply and precisely. The ELT-400 covers the wide frequency range of 1 Hz to 400 kHz (Narda, 2006).

Figure 2. The exposure level tester (The ELT-400)

Data Collection from the Students

For the second stage of the study, a qualitative research design was used in order to find out about the students' views on the electromagnetic pollution observed in the computer laboratories. The study group consisted of 36 students who had classes in the computer laboratories that were used for the study. Eight structured questions were designed to gather the data on the students' views on electromagnetic pollution. The results were interpreted by frequency and percentage analyses.

Findings

The measurements took place in four different points in the computer laboratories. Figure-3 displays the measurement points in the laboratories.

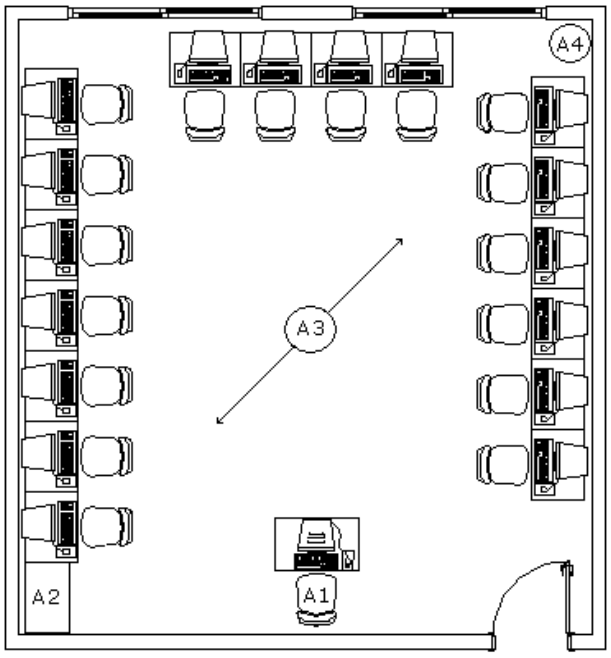

Figure 3. Measurement points in the laboratories

A_1−Next to the chair of the instructor,
A_2−Next to the UPS,
A_3−In the middle of the laboratory
A_4−On the corner further away from the UPS

The points for the measurements were first determined according to the instructor's table. However, after the first measurements it was found that the electromagnetic field levels around the UPS devices were higher than the other positions. Therefore, the measurement points were re-determined according to the position of the UPS and the measurements were repeated. The average of measurement results for four different laboratories are presented in Table 1.

Table 1. Measurement results (μT)

	A_1	**A_2**	**A_3**	**A_4**
Lab-1	0,491 μT	1,124 μT	0,528 μT	0,435 μT
Lab-2	0,702 μT	7,680 μT	0,621 μT	0,481 μT
Lab-3	0,508 μT	3,571 μT	0,572 μT	0,425 μT
Lab-4	0,538 μT	4,800 μT	0,713 μT	0,411 μT
Mean	0,576 μT	4,294 μT	0,593 μT	0,438 μT

As shown in Table 1, the electromagnetic field levels in the computer laboratories on the points A_1, A_2, A_3 and A_4 are similar (A_1=0,576 μT; A_3=0,593 μT; A_4=0,438 μT). These levels are within the exposure limits set by ICNIRP, and they don't pose a risk to health. However, in the point A_2, the electromagnetic field levels were found to be much higher compared to the points A_1, A_3 ve A_4 (A_2=4,294 μT). This result shows that the electromagnetic pollution in the places closer to the UPS device was higher than pollution in the other places. Accordingly, it was observed that the electromagnetic current rose up to the levels that threaten health conditions when moved towards the UPS and decreased when moved away from it.

This result shows that UPS devices cause more electromagnetic pollution than the other equipment. Such a case does not stem from the UPS device itself, but from the transformers inside the UPS. Many epidemiologic and experimental studies until today have concluded that high-tension lines and transformers increase the risk of cancer (Balcer and Elizabeth, 1995, p.18; Shaw and Croen 1993; NAS 1996; Tenforde 1996). The measurement levels obtained at level "A2" were within the exposure limits set by the ICNIRP and did not pose a risk to health. However, electromagnetic pollution at the points closest to the UPS device could be thought to be at dangerous levels to health. To investigate the matter further, the measurements were repeated at different distances to the UPS device and risky exposure levels were observed.

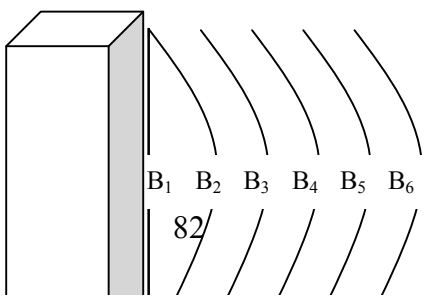

Figure 4. Measurement points for the UPS

The measurements for the UPS devices were carried out at distances of B_1, B_2, B_3, B_4, B_5 and B_6 point and the average results are presented in Table 2.

Tablo 2. UPS measurement results (μT)

	Distance	**Level**
B_1	0 cm	24,040 μT
B_2	5 cm	16,620 μT
B_3	10 cm	12,520 μT
B_4	20 cm	06,980 μT
B_5	50 cm	02,130 μT
B_6	100 cm	01,540 μT

As shown in Table 2, the measurements at the closest points to the UPS displayed dangerous levels to health. Especially, at 0 cm distance, thus touching the device, and at 5 cm distance, a considerable amount of electromagnetic pollution existed (B_1=24,040 μT; B_2=16,620 μT). These levels were above the exposure limits set by ICNIRP and posed a risk to health.

Moving on from the results obtained, analyses were carried out in computer laboratories in 24 different primary-secondary and higher education institutions in Istanbul and some risky situations were detected. It was observed from the analyses carried out at schools that the UPS devices were positioned such that they could affect the learning environments in a negative way. For instance, in many schools the UPS device was positioned at places very close to the students. Even in some schools the UPS device was put behind the last row of desks and the students at these desks leaned against the device during the lesson. There is no doubt that this poses a risk to health.

The second stage of the study consisted of the data from the interviews with the students. As the measurement levels obtained at the closest points to the UPS posed a risk to health, the devices were moved out of the laboratories to a different place. Then, one-to-one interviews were carried out with 36 of the students who were having lessons at the computer laboratories where the measurements took place and their opinions regarding the new state of the laboratories were taken.

Fourteen percent of the students stated that they had headaches when they were seated near the UPS and 33% that they felt uneasy. On the other hand, after the UPS devices were moved out of the laboratories, 86% of the students stated that noise pollution decreased and 64% that their motivation for the lesson increased. Likewise, 69% said that they felt safer and 14% that nothing has changed for them.

Discussion

Human beings are affected by interior and exterior magnetic fields that exist in nature, as well as the magnetic field pollution created by themselves, by the electrical household equipment and by high-tension lines. The devices that create magnetic fields have become a part of our lives. Therefore, we have to take possible precautions against the adverse effects of these devices. Because it is not possible to see the electromagnetic fields with the naked eye and their effects cannot be felt directly, people do not attach adequate importance. It is inevitable to spot the sources of magnetic field pollution and to take necessary precautions to prevent it (Bold, Toros and Şen, 2003, p.62). It is crucial to attract public attention to magnetic field pollution alongside air and noise pollution.

Although long term exposure to electromagnetic pollution does not cause cell deaths, it may bring about irreversible damages to the genetic structure. As it can be understood from the results of the current study, the electromagnetic pollution in the computer laboratories can reach to dangerous levels for the health of the students and the teachers. Previous studies demonstrated that electromagnetic pollution affects the neural system, causes insomnia, exhaustion, fatigue, headaches and dizziness (Bold, Toros and Şen, 2003, p.62; Şeker and Çerezci, 2000). This indirectly affects the learning environment in a negative way. In a similar vein, 64% of the students in the current study stated that their motivation increased and 69% that they felt safer after the UPS devices were removed from the laboratories.

Some countries have developed certain standards to prevent the negative effects of the electromagnetic pollution on the learning environments. For instance, in New York State, Regent Advisory Committee on environmental quality in schools recommends the following proposals such as electromagnetic field exposure and available prudent avoidance measures should be considered in the sitting, design and construction of new schools and should be considered in determining space utilization in existing facilities (Report to the New York State, 1994, p.32).

As it is impossible to totally give up on the devices that cause electromagnetic pollution, the best path to follow is to raise public consciousness. Some of the precautions that can be taken may be listed as follows; all the students and the teachers should be made aware of the effects of the electromagnetic pollution within the educational settings. Otherwise, the students can stay very close to the devices that cause electromagnetic pollution. According to the theory known as the reverse square law, the density of the electromagnetic pollution changes in adverse proportion to the square of the distance, as it is for the visible rays (Oyar, 1998). In other words, exposure to the electromagnetic field increases exponentially as you move towards the source. Therefore in educational settings, one should keep away as much as possible from the sources that cause electromagnetic pollution. For instance, the students should study at least 60 to 70 cm away from the computer screen in order to prevent the adverse effects (Erkök, 2004, p.4). Moreover, it is worthwhile to position the UPS devices, which are found to cause more pollution compared to other devices, outside the computer laboratory. When it is not possible to take the UPS out of the laboratory, it should be

positioned at least 100-120 cm away from both the teachers and the students. One of the other ways of protection from the electromagnetic pollution is to cover the device with armour (Oyar, 1998). This method can be preferred particularly for the UPS devices.

References

Arnetz, B.B. ve Berg, M.J. (1996). Melatonin and Adrenocorticotropic Hormone Levels in Video Display Ünit Workers During Work And Leisure. Journal of Occupational Environment Medicine, 38 (11), 1108–1110.

Artun, T. (2006). Bilgisayar Terminal Ekranı ve Sağlık. [www document, accessed: 25 February 2006]. URL: www.sibernet.com.tr/dr.htm

Atalay, S.N. (1999). Elektromanyetik Kirlilik ve Etkileri, Korunma Yöntemleri, WHO Uluslararası Elektromanyetik Alan Projesi, Ulusal ve Uluslararası Politikalar, Bilişim Toplumuna Giderken Elektromanyetik Kirlilik Etkileri Sempozyumu, Gazi Üniversitesi, Ankara.

Balcer, K. and Elizabeth, K. (1995). Gene Expression Flowing 60-Hz Magnetic Field Exposure. Enviromental Health Perspectives, Boston, MA.

Bold, A., Toros, H. ve Şen O., (2003). Manyetik alanın insan sağlığı üzerindeki etkisi, III. Atmosfer Bilimleri Sempozyumu, İstanbul. ISBN.975-561-236-X.

Brent, R.L., Beckman, D.A and Landel, C.P. (1993). Clinical Teratology. *Current Opinion in Pediatric*, 5(2): 201-11

Chernoff, N., Rogersm, J.M. and Kavet, R. (1992). A Review of The Literature on Potential Reproductive and developmental Toxicity of Electric and Magnetic Fields, *Toxicology*, 74 (2/3), 91-126.

Erkök, M. (2004). Bilgisayar Monitörlerinin Yaydığı Elektromanyetik Alanlar, *EMO Dergisi,* 429, Ankara.

ICNIRP Guidelines (1997*). Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields*, ICNIRP Secretariat, Institute of Strahlenhygiene, Germany.

Kalkan, T.M., Körpınar, M.A., Pişiriciler, R., Toprak, N., Birman, H. (1994). Frekanslı Manyetik Alanın, Sıçanların Vücut Ağırlıkları, Kan parametreleri ve Tavuk Embriyosu Üzerine Etkileri. Bilişim Toplumuna Girerken Elektromanyetik Kirlilik Etkileri Sempozyumu, *Türk Fizyolojik Bilimler Derneği 20. Ulusal Kongresi*, İzmir.

Narda ELT-400 (2006). [www document, accessed: 27 February 2006].
URL: www.protelturkey.com/teknik/tm/emi.htm/elt400_e.pdf

Report to the New York State (1994). Board of Regents on the Environmental Quality of Schools. Albany, NY: University of the State of New York, State Education Department.

Mittelstaedt, M. (2006). Does power corrupt? [www document, accessed: 25 February 2006]. URL: www.avaate.org/article.php3?id_article=219

Oyar, O. (1998). *Radyolojide Temel Fizik Kavramlar*, Nobel Tıp Kitabevleri, Bursa.

Sevgi, L. (2000). *Elektromagnetik Kirlilik, Cep Telefonları ve Baz İstasyonları*, EMO İstanbul Şubesi Yayınları, İstanbul.

Shaw, G.W. and Croen, L.A. (1993). Human Adverse Reproductive Outcomes and Electromagnetic Fields Exposures: Review of Epidemiologic Studies. Environ *Health Perspect*, 101, 107-119.

Şeker, S. ve Çerezci, O. (2000). *Radyasyon Kuşatması*, Boğaziçi Üniversitesi Yayınevi, İstanbul.

Tenforde, T.S. (1996). *Interaction of ELF Magnetic Fields with Living System*. In: Polk, C.; Postow, E., eds. Biological Effects of Electromagnetic Fields. Boca Raton, CRC Press.

Youbicier-Simo, B.J., Boudard, F., Cabaner, C. ve Bastide, M. (1997). Biological effects of continuous exposure of embryos and young chickens to electromagnetic fields emitted by video display units. *Bioelectromagnetics*, 18 (7), 514-23.