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Quantitative Evaluation of Electromagnetic Field Intensity at Different Metro Stations in Tehran, Iran and Comparison with the Standard Limits

Running title: Electromagnetic Fields in Metro Stations

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ABSTRACT

Background & Objective: Humans are subjected to the electromagnetic field radiation from natural and artificial human sources. Exposure to electromagnetic waves has increased exponentially with the development of technology. On the other hand, scientific research has indicated that electromagnetic fields exert important biological effects on vital systems. Therefore, electromagnetic field sources should be evaluated and controlled in order to prevent hazardous exposure. The present study aimed to quantitatively evaluate the intensity of the electromagnetic fields at different metro stations in Tehran, Iran for a comparison with the standard limits for passengers.

Materials and Methods: Electromagnetic field intensity was measured randomly using a Gauss meter in the waiting platforms and inside the train wagon in the six selected metro stations. The obtained mean values were compared with the international standards. In addition, the intensity of electromagnetic fields was compared at different stations.

Results: Intensity of the electromagnetic fields at the metro stations in Tehran was lower than the international standards ($0.24\pm0.05\ \mu T<100\mu T$). A significant difference was observed in the intensity of the electromagnetic fields at different metro stations ($P<0.05$).

Conclusion: The results showed a significant difference between the metro stations in Tehran, Iran in terms of electromagnetic field intensity. However, since the electromagnetic field intensity in the selected metro stations was lower than the standard limits, it could be concluded that exposure to these sources has no hazardous biological effects on the passengers.

Introduction

With the advent of technology in the modern era, exposure to electromagnetic waves in the human environment is on the rise. Electromagnetic waves are considered to be among the most harmful elements of modern contamination, and their adverse effects have been widely reported over the past few decades [1].

Epidemiological studies on the populations living near high-voltage power lines have denoted the high incidence rate of various diseases compared to other areas. Electromagnetic fields with high intensity and high frequency impair the nervous system, promote the growth and repair of cells, and increase the incidence of conditions such as lymphoma, leukemia, brain tumors, and fertility disorders in men and women.

Non-ionizing electromagnetic radiations mostly have frequencies of less than 2×10^{16} Hz. These radiations are classified into three categories, including the frequencies higher than 1 GHz (e.g., microwaves, infrared, and optic light), frequencies higher than 3 kHz and lower than 1 GHz (e.g., communication systems), and frequencies lower than 300 Hz, which are known as extremely low frequency (ELF) fields [2, 3].

Unlike high-frequency radiation, the electric and magnetic fields in the ELF range are investigated separately. The electrical component rarely penetrates into the body, and its penetration is only through hair and skin in the high fluxes of EMF.

However, the magnetic component penetrates into the body without weakening and appears with the electric current flux, resulting in the generation of a constant magnetic field by direct flow [4].

Previous studies have investigated the effects of ELF magnetic fields with a wide range of intensities, frequencies, waveforms, and radiation durations on the cell, tissues, and animals. Dosimetry has been the method of choice to describe radiation in these studies. The parameters assessed in the studies on ELF include field specifications, radiation time, physical mechanisms of radiation (whole-body or localized radiation), field intensity, alternating current (AC)/direct current (DC) frequency (sine or pulse) or signal waveform, harmonics, field direction (linear/polarizing), physical dimensions of radiation objects, applied equipment, and electromagnetic field [5].

Evidence suggests that magnetic fields in biological systems have specific effects on extremely low energies, and physiological responses are only observed in certain magnetic field parameters. Furthermore, mechanisms of influencing these fields have been proposed. Static electromagnetic waves and variable electromagnetic waves exert different physical and biological effects on the body with time [6, 7].

Static magnetic fields (SMFs) have several biological effects on biological systems and organisms through five mechanisms of motion-induced current, Lorentz force, magnetic force, magnetic torque, and effect of radical pairs. In addition, SMFs have a pure force on paramagnetic and ferromagnetic materials, which alters their motion (interaction with free radicals) at low SMFs. The intermediate conditions of free radicals with low-intensity static magnetic fields affect electronic spin states. Weak magnetic fields with a size of B=50 μT could also impose significant forces on magnetic particle chains in specific samples of organisms [8-10].

The biological effects caused by time-varying magnetic fields are simpler than the SMFs and include nerve stimulation due to eddy currents and effect of higher frequencies. Figure 1 shows the physical and biological effects of static and time-varying magnetic fields. The limits of ELF exposure have been determined by the International Commission on Non-Ionizing

Radiation Protection (ICNIRP) for preventing the effects of the current densities that are higher than the internal current (10 mA/m²). Based on the ICNIRP standards, at a frequency of 60 Hz, the radiation exposure limit for the magnetic field is 0.0833 mT for the general population and 0.4166 mT for occupational exposure. At a frequency of 50 Hz, the limit has been estimated at 100 and 500 μT for the general population and workers, respectively [11-13].

The present study aimed to quantitatively evaluate the intensity of the electromagnetic fields at different metro stations in Tehran, Iran for comparison with the standard limits for passengers.

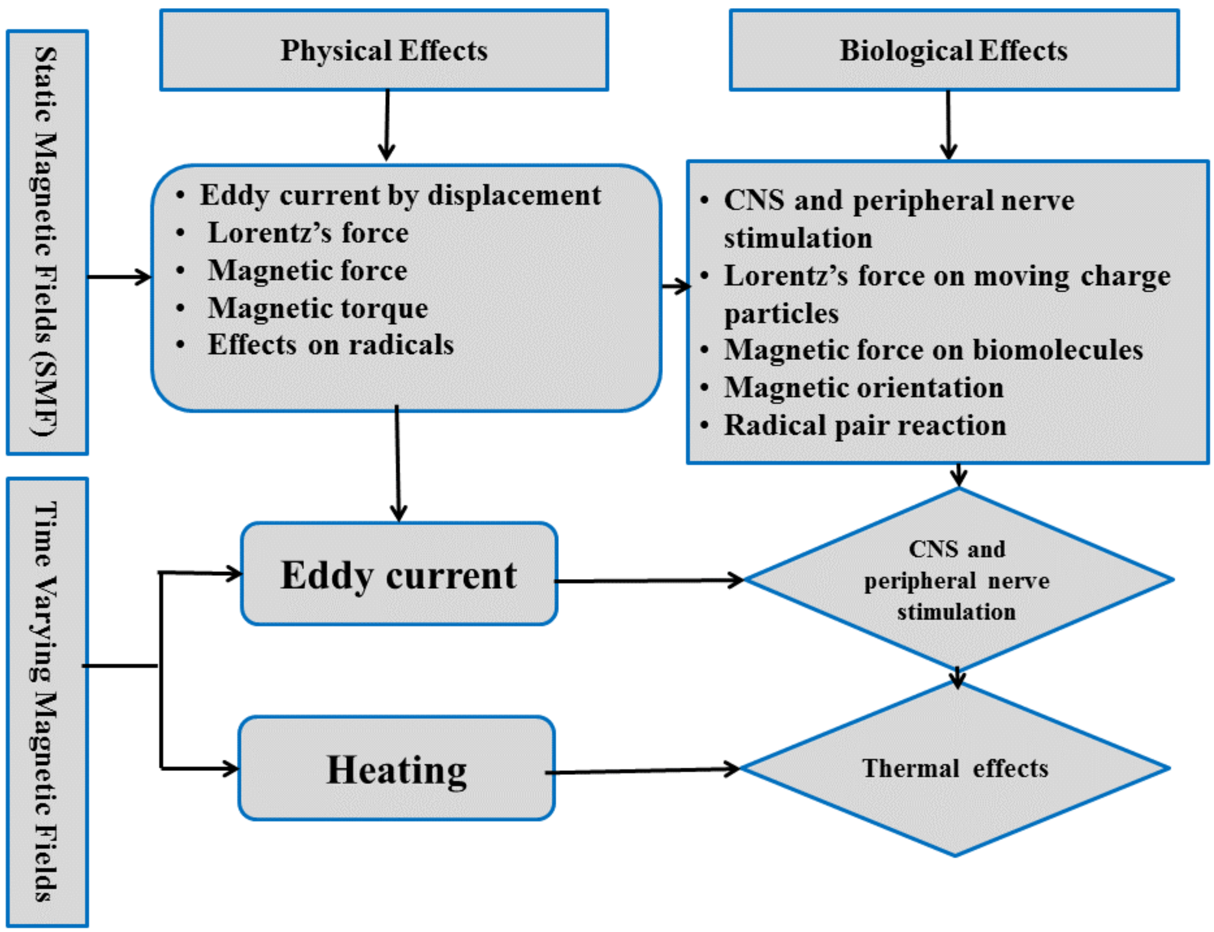

Figure 1. Showing the physical and biological effects of static and time-varying electromagnetic fields on biological systems.

Materials and Methods

This study was conducted in the metro system of Tehran city. At each station, a transformer was used for converting the voltage of 20 kV into 750 V DC, feeding the train from the ground, and DC electricity of 750 V. Six metro stations in Tehran were selected randomly, and the intensity of the electromagnetic fields of 10 points was measured using a hand-held Gauss meter (model unit: Lutron EMF-827, made in Taiwan).

The measurements were performed while passengers waited for the train (i.e., on the waiting platform) and when the train was moving (i.e., inside the train). All the measurements were carried out at a height of 1.5 meters from the ground (at the waist line).

Results

The measured values in the study are shown separately using bar graphs. Mean values for the intensity of electromagnetic fields at six stations are depicted in Figure 2. Mean electromagnetic field inside the train at 10 points in Molavi-Shoosh route is shown in Figure 3. Comparison of the permissible intensity of the electromagnetic fields and mean electromagnetic field intensity on the waiting platform and inside the moving train are illustrated in Figures 4 and 5, respectively.

Findings of the current research indicated no significant difference between the intensity of the electromagnetic fields at the metro stations with the standard radiation limits. However, a significant difference was observed in the measured electromagnetic fields at six metro stations ($P<0.05$).

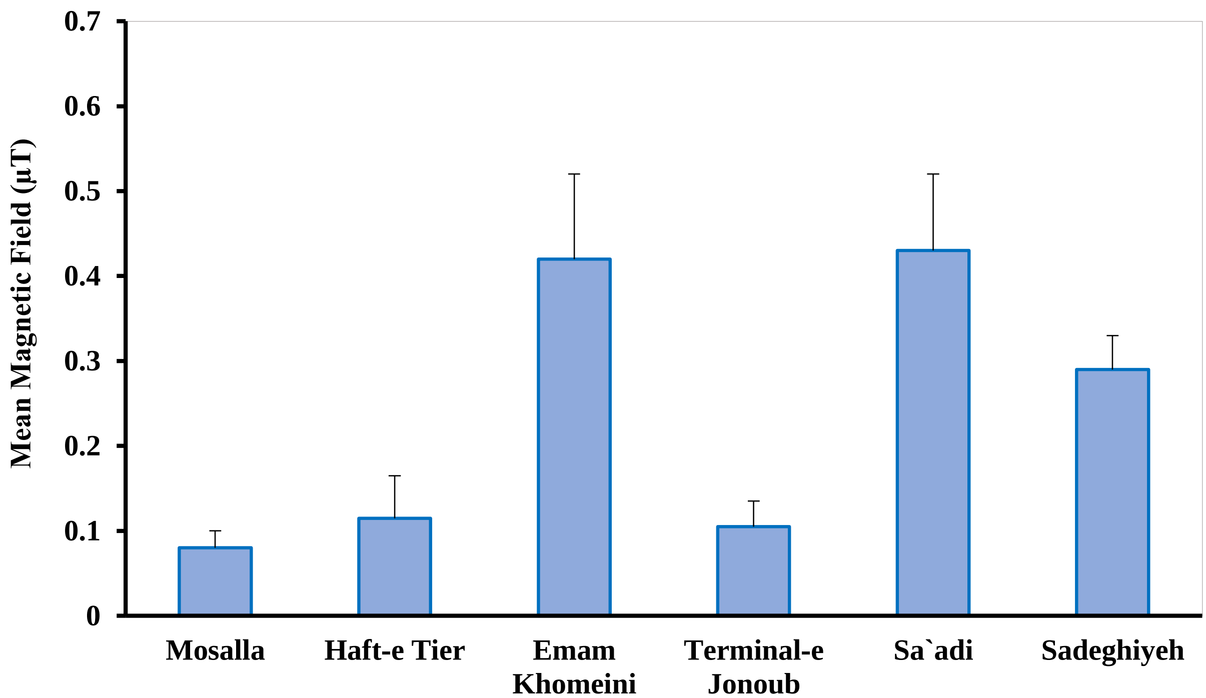

Figure 2. The mean electromagnetic field intensity (µT) measured at six different metro stations in Tehran on the waiting platform.

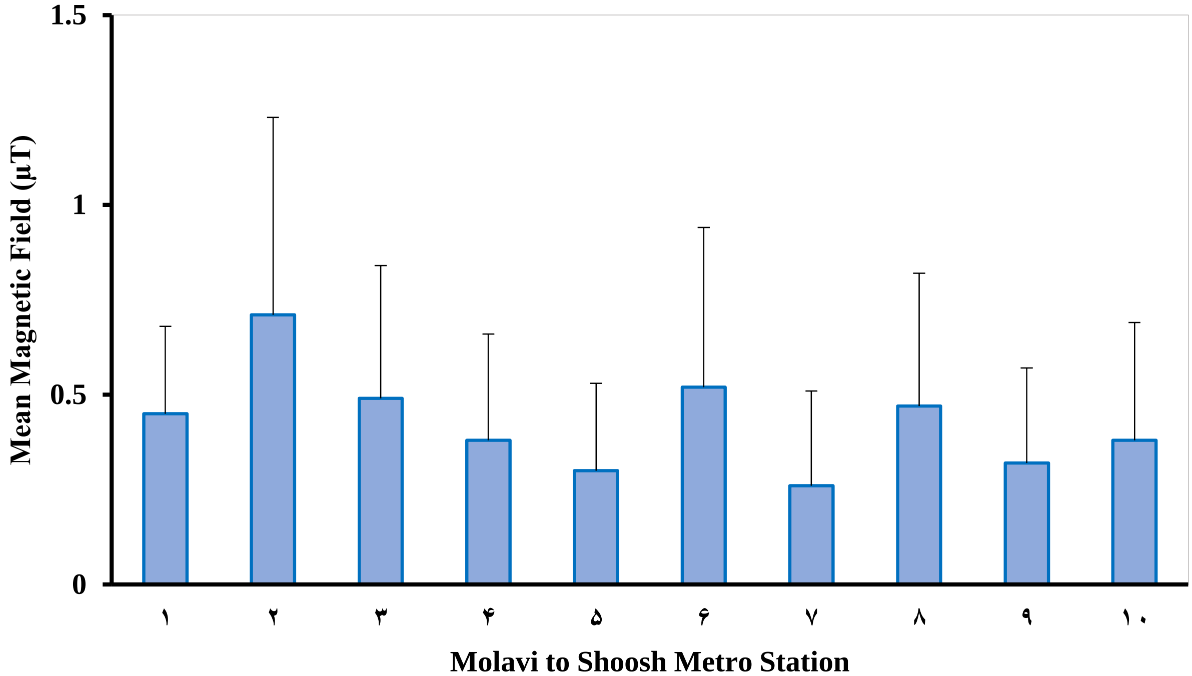

Figure 3. The mean electromagnetic field intensity (µT) measured inside the moving train between different metro stations of Tehran in the direction of Molavi-Shoosh route.

Discussion and Conclusion

Urban and interurban transportation systems cause numerous environmental problems due to the release of air pollutants. In the 21st century, most of the countries across the world, including Iran, have attempted to move toward the use of clean fuels. As such, use of electrical technology and hybrid systems has been further developed to prevent the release of hazardous pollutants from fossil fuels. The rail transport system is an example of using clean energy, which is currently at the disposal of passengers in many countries [14]. Despite the advantages of electric rail systems, the presence of electromagnetic fields in the applied technology is one of the most polluting elements for humans.

Several studies have been published on the effects of electromagnetic waves on the environment and biological systems. In some cases, studies have been conducted to measure the intensity of electromagnetic fields in public transport systems, including metro stations and hybrid vehicles. Moreover, major investigation has been focused on the exposure and radiation levels in the drivers of electric and hybrid transport vehicles with ELF electromagnetic fields [15-17]. Considering the paramount importance of the health of subway passengers, the authors of this paper aimed to assess and measure the intensity of the electromagnetic fields at Tehran metro stations in order to further study its biological effects.

Findings of the current research demonstrated no significant difference in the intensity of the electromagnetic fields in the selected metro stations (n=6) in Tehran with the international standards (mean: 0.24±0.05 µT). Therefore, it could be concluded that based on these standards, exposure to the magnetic fields in metro stations is associated with no adverse health consequences in individuals

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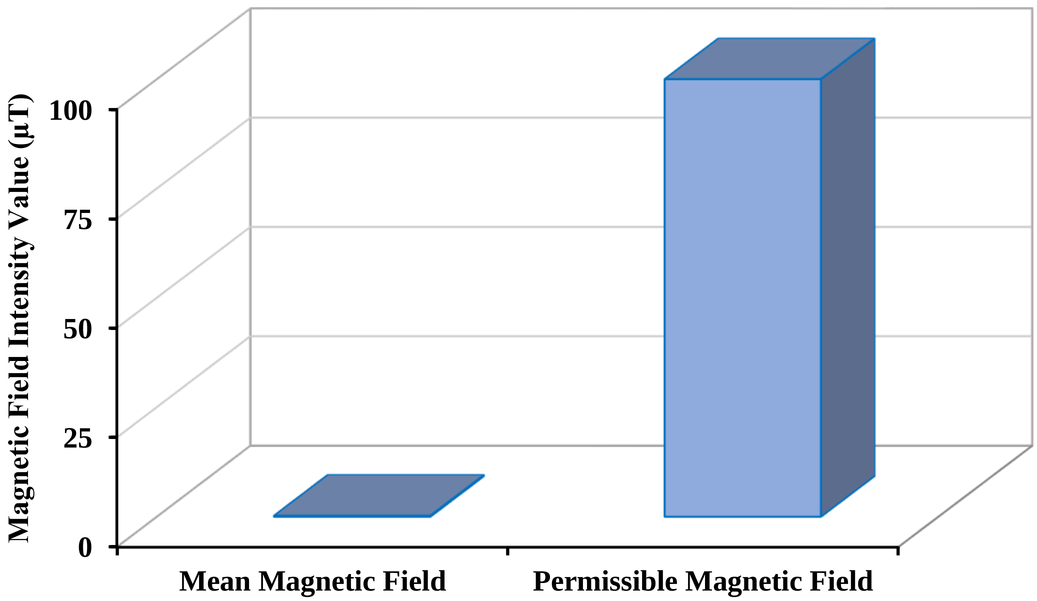

Figure 4. Comparison of the permissible intensity of the electromagnetic field and mean electromagnetic field intensity on the waiting platform.

In a similar study, mean ELF magnetic field intensity was reported to be 0.35±0.22 and 0.45±0.53 µT for DC and AC trains, respectively [18]. In another research performed in Italy, the exposure of metro drivers to magnetic fields in the corridors and in-carriages of seven trains was 163 µT on average [19]. In the electric trains in London (United Kingdom), mean steady-state flux in the passenger carriages was 16-64 µT, while it was 1,000 µT at the seat height and floor level [20].

Although in some cases, as in the present study, radiation exposure in passengers and personnel has been shown to be lower than the standard limits, individuals in subway stations must maintain a suitable distance (a minimum of one meter) from the locations close to the high-power posts in order to prevent unwanted exposure to non-ionizing radiation. Of course, this should not be the basis for deciding on the safety of extremely low-frequency and static electromagnetic fields.

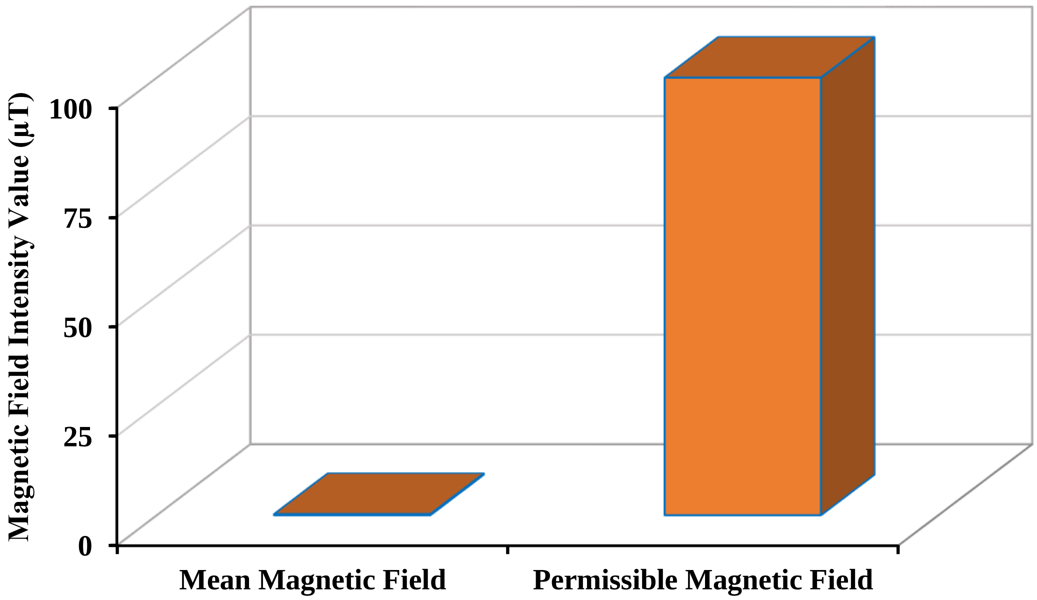

Figure 5. Comparison of the permissible intensity of the electromagnetic field and mean electromagnetic field strength inside the moving train.

Some studies have reported the occurrence of various biological conditions (e.g., leukemia) in the personnel employed in rail transport systems due to the low intensity of electromagnetic fields. Undoubtedly, accurate sensory devices (e.g., dosimeter) are required to measure the electromagnetic fields of potential community resources, such as metro stations, telecommunication antennas, and mobile devices. According to the World Health Organization (WHO), any harmful effect on human health is a universal phenomenon, and the adverse effects of magnetic fields on the health of individuals indicate the paramount importance of examining these fields in metro stations.

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Conflicts of interest: None declared.

References

1. Sadafi HA, Mehboodi Zh, Sardari D. A review of the mechanisms of interaction between the extremely low frequency electromagnetic fields and human biology. Progress In Electromagnetics Research Symposium 2006, Cambridge, USA, March 26-29
2. Mahna A, Firoozabadi SM. Environmental 50Hz Magnetic Fields Can Increase Viability of Human Umbilical Vein Endothelial Cells (HUVEC). Iran J Med Phys. 2016;13(2):100-108
3. Crumpton MJ. The Bernal Lecture 2004 Are low-frequency electromagnetic fields a health hazard? Philos Trans R Soc Lond B Biol Sci. 2005(29);360(1458):1223-30
4. Wood AW. Extremely low frequency (ELF) electric and magnetic field exposure limits: rationale for basic restrictions used in the development of an Australian standard. Bioelectromagnetics. 2008;29(6):414-28.
5. American Industrial Hygiene Association. AIHA expanded position statement on extremely low frequency electric and magnetic fields. AIHA J (Fairfax, Va). 2002;63(6):678
6. Zecca L, Mantegazza C, Margonato V, Cerretelli P, Caniatti M, Piva F, Dondi D,Hagino N. Biological effects of prolonged exposure to ELF electromagnetic fields in rats: III. 50 Hz electromagnetic fields. Bioelectromagnetics.1998;19(1):57-66.
7. Panagopoulos DJ, Karabarbounis A, Margaritis LH. Mechanism for action of electromagnetic fields on cells. Biochem Biophys Res Commun. 2002;298(1):95-102
8. Engstrom S. Physical mechanism of non-thermal extremely low frequency magnetic fields effects. Radio Science Bulletin. 2004; 311:95-106
9. Adir RK. Static and low frequency magnetic fields effects. Rep Prog Phys. 2000;63(3): 415-457.
10. guidelines for limiting exposure to time-varying electric and magnetic fields (1 hz to 100 khz). International Commission on Non-Ionizing Radiation Protection. Health Physics. 2010;99(6):818-836.
11. Chiabrera A, Grattarola M, Viviani R. Interaction between electromagnetic fields and cells: Micro electrophoretic effect on ligands and surface receptors. Bioelectromagnetics.1984;5(2): 173-191.
12. Valberg PA, Kavet R, Rafferty CN. Can low-level 50/60 Hz electric and magnetic fields cause biological effects? Radiat Res. 1997;148(1):2-21. Review.Erratum in: Radiat Res 1997;148(5):528
13. Yamaguchi-Sekino S, Sekino M, Ueno S. Biological effects of electromagnetic fields and recently updated safety guidelines for strong static magnetic fields. Magn Reson Med Sci. 2011;10(1):1-10. Review. PubMed PMID: 21441722.
14. Halgamuge MN, Abeyrathne CD, Mendis P. Measurement and analysis of electromagnetic fields from trams, trains and hybrid cars. Radiat Prot Dosimetry.2010;141(3):255-68.
15. Minder CE, Pfluger DH. Leukemia, brain tumors, and exposure to extremely low frequency electromagneticfields in Swiss railway employees. Am J Epidemiol. 2001; 153(9): 825-35.
16. Röösli M,Lörtscher M, Egger M, Pfluger D, Schreier N, Lörtscher E, et al. Leukaemia, brain tumours and exposure to extremely low frequency magnetic fields: cohort study of Swiss railway employees. Occup Environ med. 2007; 64(8): 553-9.
17. Markov MS. Effects of electromagnetic fields on biological systems. Electromagn Biol Med. 2013;32(2):121-2

18. Jalilian H, Najafi K, Monazzam MR, Khosravi Y, Zamanian Z. Assessment of Static and Extremely Low-Frequency Magnetic Fields in the Electric-Powered Trains. International Journal of Occupational Hygiene. 2017;9(2):1-11.
19. Contessa GM, Falsaperla R, Brugaletta V, Rossi P. Exposure to magnetic fields of railway engine drivers: acasestudy in Italy. Radiat Prot Dosim. 2010; 142(2-4): 160-7.
20. Chadwick P, Lowes F. Magnetic fields on British trains. Ann Occup Hyg. 1998; 42(5): 331-5.