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EVALUATION OF RESIDENTIAL EXPOSURE TO MAGNETIC FIELD PRODUCED BY POWER LINES NEAR HOMES AND WORKING ENVIRONMENTS

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Abstract

This work presents the survey of magnetic field measurements taken around the high and medium voltage power lines, and induced current densities, at the outer edge along the body heights with different body types, calculated by using real data. Survey was carried out in city of Antalya, Turkey. There, more then 2,000 families, about 200 workers and a thousand of primary school students are in the focus of this study. Surveyed region in this study in ±75m band of power lines is reading a magnetic field between 1μT and 5.2 μT, bedrooms in the apartments are reading up to 0.7 μT, and class rooms are reading up to 0.35 μT in the surveyed region. Induced internal electric fields and current densities in the occupants' body due to exposure to external magnetic fields produced by a conventional power lines such as 380,154 and 34.5 kV (50Hz) have been investigated. Induced current density for 5 years old child is calculated as about 10 (μA/m^2), and 15 (μA/m^2) for average man.

Keywords: *Power line, magnetic field; residential areas; exposure analysis*

1.Introduction

Power Lines usually produce high level magnetic fields, even though the magnetic field itself does not depend on the voltage. Currents in power lines vary over the course of a day, seasonally and from year to year as electricity demand varies. This affects the magnetic field both directly and also because the load carried affects the conductor temperature and hence sags and ground clearance. Lines usually operate at significantly less load than their rating, and therefore average magnetic fields encountered are usually significantly less than the theoretical maximum field a line is capable of producing[1]. Power subsystems drive very high-electric current densities that result in an accumulating exposure to electric, magnetic and electromagnetic fields; such exposure can cause health problems if systems are designed without reference to standards [2]. Growing interest in epidemiological studies aimed at establishing possible links between exposures, whether residential or occupational to power frequency fields and the onset of a number of diseases, including cancer and leukemia, have been witnessed in the last few years. Some epidemiological studies have found weak associations between exposure to power-frequency EMFs and some forms of cancer, such as leukemia; while other studies have failed to find such associations. The most significant and replicated findings are an apparent change in ion flux at cell membranes in response to limited ranges and intensities of ELF electric fields, an effect of ELF magnetic fields on melatonin production, and effects on enzyme activity. It is also known that ELF fields are to interact with tissues by inducing electric fields and currents in them. This is the only established mechanism of action of these fields. However, the electric currents induced by ELF fields commonly found in our environment are normally much lower than the strongest electric currents naturally occurring in the body such as those that control the beating of the heart. The International Agency for Research on Cancer (IARC) classified extremely-low-frequency magnetic field

(ELF-MF) exposure as a possible human carcinogen primarily based on the results of the two pooled analyses reporting approximately 2-fold increase in childhood leukemia risk in association with residential exposure to ELF-MF greater than 0.4 micro-Tesla (μT) [3, 4, 5].

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia[6]. Scientists [7,8,9] observed an increased leukemia risk for children in one or more exposure group, and the risks of adult cancer based on residential exposure to ELF-EMF have been evaluated in a number of studies. Risks of leukemia (of all types and of specific sub-types) from residential exposures were evaluated in several recent studies [10,11,12,13,14]. The author's conclusions are that mainstream scientific opinion now holds that there are likely significant risks although controversy still exists. Childhood leukaemia, depression and suicide, lung cancer and respiratory ailments, breast cancers are amongst the significant findings. Coleman et al [15] studied 771 adult leukaemia cases in Southeast England diagnosed between 1965-1980 with regard to closeness to high voltage lines. Coleman et al reported that for the people living less than 50 meters from line risk of adult leukaemia doubled while for the people living between 50 to 100 meters risk increased 33%.

The aim of this study is the absence of electromagnetic fields exposure safety band for power transmission lines used in Turkey, and child population is dominant around these residential areas. However, there is little information available on power-frequency magnetic fields in residences in Turkey. With a view to conducting a comprehensive research of exposures in Turkey, conducted a pilot study of power-frequency magnetic field levels in private residences in the residential area of Antalya, Turkey. This study aims to evaluate possible health risks of power lines, and to offer safety band standards to protect people. This research represents the magnetic field measurements through the residential areas, homes, schools and working environment near the power lines. Such that, one region is lying under through the high voltage power lines; the others are condominiums constructed next to the power lines. It is demonstrated that more than 2,000 families are exposed to above the 0.3-0.4 μT magnetic field intensities. Measured data have also been used for induced current calculations in human body.

2. Magnetic Field Measurements

Measurements were made by using ELT-400 Exposure Level Tester, Narda Safety Test Solutions, Wandel & Golterman, Germany. The meter measured the root mean square (rms) magnetic field intensity in each of three orthogonal directions and recorded the resultant magnitude. Different locations were selected for surveying. First measurement was made in an area where as shown in Figure 1. These power lines are cutting north part of the city towards the switchyard, and its length through suburban region is about 15km.

Fig.1. Suburban residential surveying area.

Second measurement location is chosen as an area that shopping centre including bazaar and condominiums which were constructed intentionally; instead there were power lines (154kV with four circuits, 50Hz) as shown in Figure 2. Third measurement was measurement at the school near the power lines. Figure 3 represents the magnetic field measurements with respect to distance from 380kV power transmission lines. As seen from the Figure 3 that measured magnetic field at 60m distance is about 0.22μT. As depicted at survey regions that there about 2,000 residential houses are next to those power lines and undefined safety corridor for power lines.

Fig.2. Intentionally constructed shopping centre and condominiums.

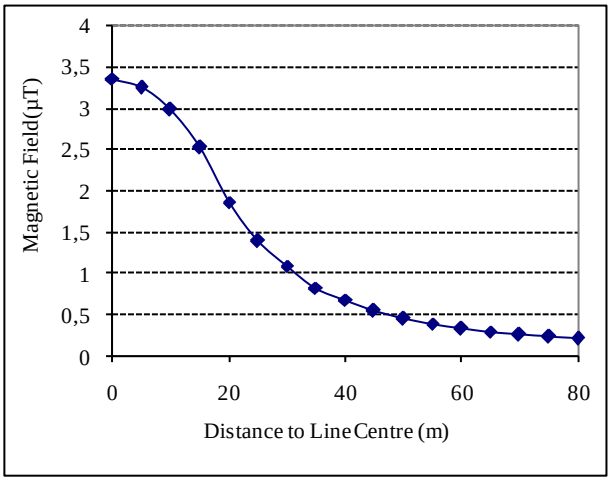


Fig.3. Magnetic field measurement with respect to distance from 380kV power lines.

Figure 4 represents magnetic field variation with respect to ground height. Upper most two points (160cm and 180cm) refer to the human head position. Figure 5 represents the magnetic field variation with respect to distance at maximum flesh region. As expected, flesh region reads 50% more magnetic field and reaches up to 5.2 µT. Meanwhile, 20% of those 2,000 houses are located around flesh region which means that 400 houses have 50% more extra risks.

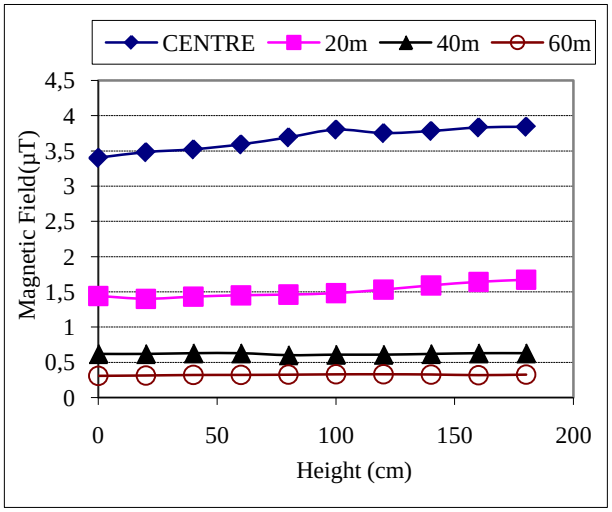


Fig.4. Magnetic field measurements with respect to human height from ground at different locations.

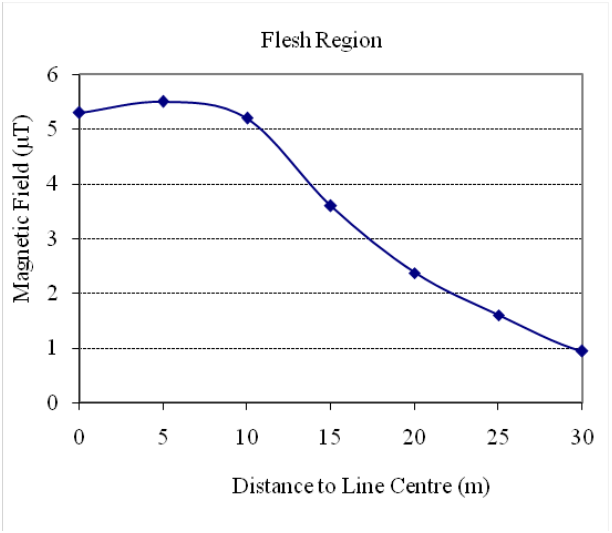


Fig.5. Magnetic field measurements with respect to distance from power lines at flesh region

Figure 6 and Figure 7 represent the measured magnetic field at Varsak Shopping Centre. There are two lines of shops lying parallel to each other at a distance of 40m, and that 40m gap is used as a bazaar covered by awning, but there are also no shielded and/or awning under shops. While bazaar covered by awning is reading about 0.3µT, shops located at north part of bazaar are reading about 0.45µT. Figure 6 represents the reading obtained at south of bazaar parallel to Varsak Boulevard. At this part there is extra one high voltage transmission line is present. While sidewalk (depicted as open in the figure) is reading about 3µT, in-shop reading is about

1μT for 34.5 kV medium voltage lines. Owners are mostly spending their time at sidewalk to catch a customer, and exposed to 3μT of magnetic field. One owner and one worker (160 in total) are working about 10 hours a day in this region. Government needs to be take precaution to protect those people from possible health risks.

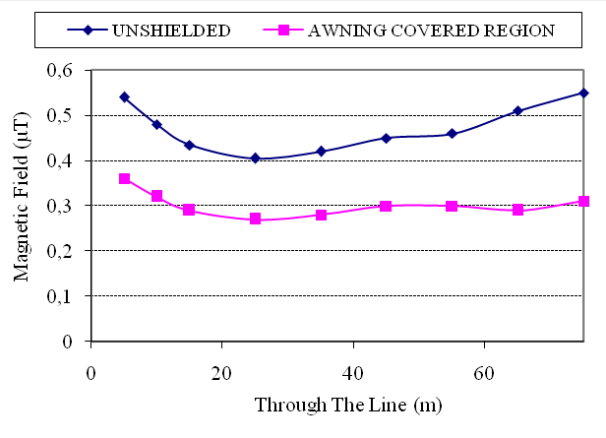


Fig.6. Magnetic field measurements through the line at North Part of Varsak Shopping Centre

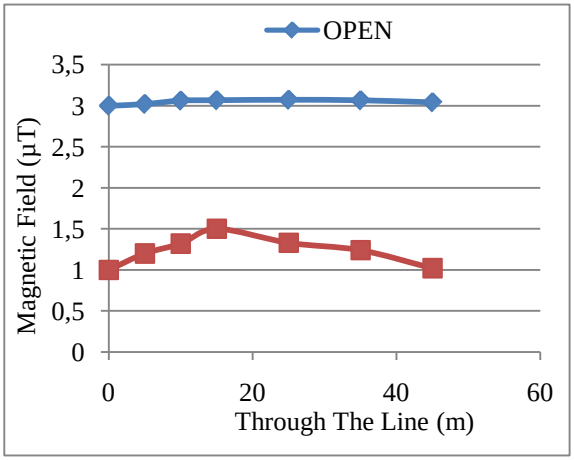


Fig.7. Magnetic field measurements through the line at South Part of Varsak Shopping Centre

Fig.8. represents measurements taken at different rooms of different floors of 15 floors apartment that was 12m apart from the high voltage power line depicted in Figure.2. There are four blocks and each block has 15-floors building, and each floor has three apartments. At this condominium, 180 families are staying, there four more condominium in such conditions at this region. During the measurements, apartments at different floors were selected such that at least one 0-12 age kid is living inside. Red transparent band is the lower limit which the child leukemia arises, and a magnetic field value inside the kids' rooms is sometimes 0.7μT. Stairs lying trough the centre of each building reading value in a risk region, and elevator reads about 0.3μT while doors are closed. As seen in figure 8, maximum magnetic field value was measured in the floor 11.

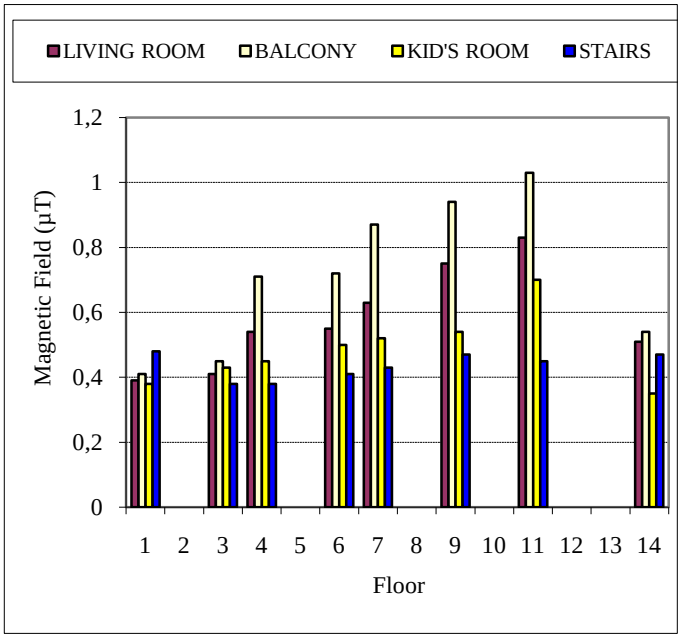


Fig.8. Magnetic field measurements at 15 floors apartment.

3. Iduced Current Density Human/Child Body Due To Power Lines Magnetic Fields

The interaction of time varying electric fields with the human body results in the flow of electric charge(electric current), the polarization of bound charge(for motion of electric dipoles), and reorientation of electric dipoles already present in tissue. The relative magnitudes of these different effects depend on the electrical properties of the body – that is, electrical conductivity and permittivity. Electric conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field. Electric fields to the body induce a surface charge on the body; these results in induced currents in the body, the distribution of which depends on exposure conditions, on the size and shape of the body, and body's position in the field.

To determine the current density that is induced inside body standing different locations in 380kV, 154kV and 34.5kV power transmission lines vicinity. The human body is simulated as prolate spheroid [16]. According to Faraday's law, a changing external magnetic field produces an internal electric field inside the body. Thus, the internal induced electric field components can be expressed by the following equations:

$$\overline{E}_x = j\omega\left(\frac{zB_y}{2} - \frac{b^2 yB_z}{a^2 + b^2}\right) \tag{1}$$

$$\overline{E}_y = j\omega\left(\frac{a^2}{a^2 + b^2}\right)\left(xB_z - zB_x\right) \tag{2}$$

$$\overline{E}_z = j\omega\left(\frac{b^2 yB_x}{a^2+b^2} - \frac{xB_y}{2}\right) \tag{3}$$

where B_x, B_y, and B_z are the three components of the external magnetic field and ω is the angular frequency the external magnetic field.

Total electric field E induced inside the body can be expressed by Eq.4

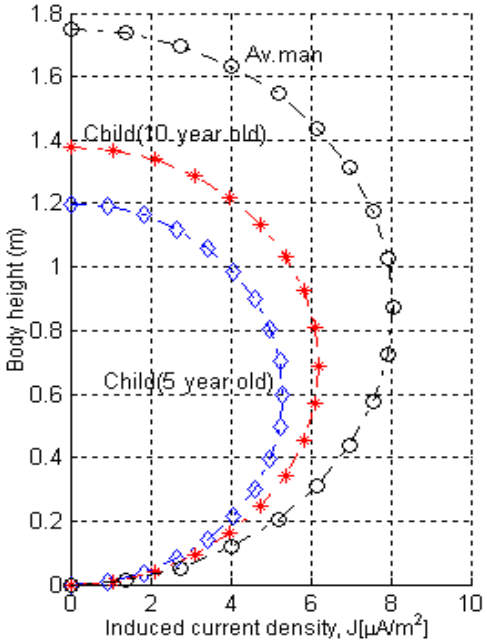
$$E = \sqrt{\left(E_x^2 + E_x^2 + E_x^2\right)} \tag{4}$$

and the current density $\vec{J}$ induced inside the body by the internal field can be determined as:

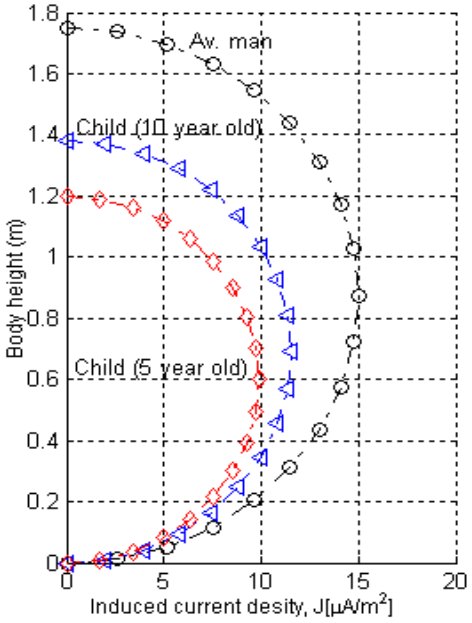
$$\vec{J} = \sigma\vec{E} \tag{5}$$

Where σ is the electric conductivity of the body tissue (S/m). Here, because we are dealing with he biological body and considering the ELF magnetic field, we have $\sigma >> \omega\varepsilon$ (ε; permittivity of the body), and so the displacement current component is neglected [17,18,19]. The second-order magnetic field due to the current induced inside the model is also neglected. For this reason, the magnetic field inside the body can be regarded as uniform.

Here, the frequency of external magnetic field produced power lines is 50 Hz and the conductivity of the body is 0.2 S/m [20]. The investigated the effect of the human size and age on the magnetically induced current densities inside the body, average man, 10 year old child, 5 year old child body models are employed. The prolate spheroid body parameters can be seen detailed in [21]. Figure 9 represents internal induced current densities at the outer edge along the body height with different body types. For different body models such as children and average man, maximum values of induced current densities occur at and are proportional to the human's mid height.



(a) 20m from 380 kV power line



(b) Under the center of 380 kV power line

Fig.9. The internal induced current densities for different human body.

Figure 10 represents the induced current to the 10 years old child and adult body who are living around the 380kV power transmission lines with respect to distance from power line

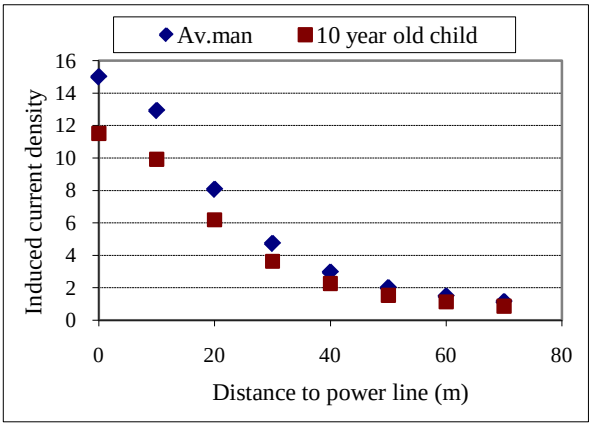


Fig.10. Induced current variations ($\mu A/m^2$) adult and 10 years child body

4. Conclutions

Through the suburban residential region; measured values are varying between 0.22μT (at 80m far from the line) and 5.3 μT (under the centre line), there are two primary schools in survey area, and magnetic field levels are varying between 0.2 μT and 0.54 μT for different

locations of schools and school garden. In house measurements were repeated for 500 houses for 160m corridor of through 380kV power lines, and values are varying between 0.23 μT and 1.4 μT.
Another surveying area (bazaar) is reading a magnetic field value of about 0.3μT under awning, 1.5μT in shops, and 3 μT at sidewalk. Third surveying area is a condominium 12m next to high voltage power lines, and readings are 0.3μT in elevator, 0.4μT in stairs, 0.42μT to 0.83μT in living rooms, 0.5 to 1.03μT in balcony and 0.5μT to 0.7μT in child bedrooms. Induced current calculations are 13.309 $\mu A/m^2$ under 34.5kV transmission lines, 6.503 $\mu A/m^2$ in shops, and 1.56 $\mu A/m^2$ through the bazaar which is shown at Figure 2.

The maximum values of the magnetic fields discussed above were below the Standard level of The International Commission on Nonionizing Radiation Protection (ICNIRP): 500 μT for occupational exposure and 100 μT for general public. ICNIRP occupational reference level for induced current is specified as 10 mA/m^2 in the frequency range 4 Hz to 1 kHz, and general public reference level is specified as 2 mA/m^2 in the same frequency range[22]. Current densities induced by actual magnetic field levels stay under the basic ICNIRP restrictions. However, the values of magnetic fields grater than 0.4μT were measured in homes, working environments and schools. For these types of regions, epidemiological and biological studies should be taken into account for low level magnetic field strength.

If the studies for health effects of high voltage transmission lines are taken into account [23,24,25,26] an epidemiological research needs to be enforced. Results show that awning has a considerable shielding capability. That's why shielding possibilities should be investigated and applied under the support of government authorities. New construction power line projects should contain safety corridors and its definition.

***Acknowledgement**:*

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