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Residential Area Medium Voltage Power Lines; Public Health, and Electric and Magnetic Field Levels

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ABSTRACT

In this study, the electric and magnetic fields occurred around the medium voltage power distribution lines (MV-PDL) in the residential area have been analyzed, and different MV and LV power distribution lines (PDL) in Antalya were selected in order to investigate the electromagnetic field exposure according to yearly-based current load on power lines. Knowledge of magnetic field levels determined around power lines is so important for completing acceptable epidemiological studies, and medium voltage power lines established in the residential area close to the apartments have been investigated. There are houses and apartments in a distance of 10m or less which have potential for child leukemia, since magnetic field levels are around 0.4 µT and up.

Keywords: Annual Power Demand, Medium Voltage Power Lines, Electric and Magnetic Field, Public Health, Safety Standards

1. INTRODUCTION

The electric power transmission lines and substations produce extremely low frequency (ELF) electric and magnetic fields. During the past 35 years, the general public has become increasingly concerned about potential health hazards of exposure to ELF electric and magnetic fields induced by PDL. There are a lots of studies concerning about the effect of electric and magnetic field on biological tissues [1,2]. Especially, power frequency magnetic fields have been suspected of causing various types of negative health effects. Many researchers and people are concerned with relationship between exposure to ELF electromagnetic fields and the increased risk of cancer [3,4]. Concern has concentrated on magnetic rather than electric fields and on childhood leukemia in particular [5,6,7].

Researchers 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 [8,9]. It has been reported that leukemia risk for adults living in the field of 50m or less to the power transmission lines is 33% higher than those living in the range of 50m to 100m [10-14].

National Institute of Environmental Health Sciences (USA) accepts a level of 0.3-0.4µT as a leukemia level, and IARC member of WHO put this level into the Group-B [15,16,17]. There are lots of reports that long term exposure more than 0.4µT, and few studies about 0.2µT exposure increases leukemia risks [12-17]. Average magnetic field level in houses and offices are around 0.1mT, which is 1000 times higher than this ratio next to the current loaded conductors [18]. Electric field level reaches to the 10kV/m around

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ground level. In residential studies, the adverse health effects have been associated with magnetic field exposure, specifically, since the electric field generated by power lines does not penetrate buildings. People are exposed to electric fields from power lines and transformers only when they are outdoors.

In recent years, the evidence that power frequency electromagnetic fields have adverse biological and health effects continues to amount for childhood cancers at residential exposure [8,19], following parental exposure and for occupational cancers including leukemia, brain cancer, and breast cancer [20,21]. Some of the evidence for electromagnetic field exposure also includes increased risk of miscarriage [22] neurodegenerative diseases such as amyotrophic lateral sclerosis and Alzheimer's disease [23].

The limit recommended by the (International Non-ionizing Radiation Committee) ICNIRP [10] for the public at 100μT (1000mG) is considerably higher than 0.4μT (4mG), the level at which there appears to be a statistical link with a doubled risk of development of childhood leukemia [24].

Limited works are available in the literature, which deals with long term magnetic field variation around the power transmission lines. In this study, electric and magnetic field occurred around the MV-PDL have been examined. Magnetic fields occurred around power lines have been investigated according to yearly-based load variation in order to make long-term analysis. A knowledge of magnetic field levels determined around power lines is so important for completing acceptable epidemiological studies and for concluding those surveys. Electric field levels were determined by using charge simulation method, and magnetic field levels depending on power demand thought the annual period were determined by using Biot-Savard's law and real time measurements.

2. ELECTRIC AND MAGNETIC FIELD PREDICTION

2.1. Charge Simulation Method

In this paper, the Charge Simulation Method (CSM) has been presented to compute the high voltage transmission line electric fields [16]. Method allows us to calculate electric potential V_i at any point either at the surface of a conductor or in the insulating region (between the conductors) by the summation of the potential contribution of all the individual simulation charges using the Eq.1.

$$V_i = \sum_{j=1}^{n} p_{ij} \cdot q_i \qquad (1)$$

Where P_{ij} is the potential coefficient related to the potential of the j[th] charge at the i[th] point, q_i is the simulation charges, n is the charge number. If line charge is selected, the potential coefficients can be written as in Eq.2.

$$P_{ij} = \frac{1}{2\pi\varepsilon} \ln\left(\frac{(x_i - x_j)^2 + (y_i + y_j)^2}{(x_i - x_j)^2 + (y_i - y_j)^2} \right)^{1/2} \qquad (2)$$

Where, ε=8.85*10-12 F/m dielectric constant of air, (yi, yj) heights of conductors i and j above ground; (xi, xj) horizontal coordinates of conductors i and j [26].

In the case of number of contour points equal to the number of simulation charges; linear equations for the potentials of contour points can be written as in Eq.3.

$$[P] \cdot [Q] = [V] \qquad (3)$$

where [P] is the potential coefficient matrix, [Q] is a column vector for simulation charges, and [V] is a column vector for potentials of contour points. The potential values of these points are known and equal to the applied voltage of the conductors. The values of simulation charges are computed first by solving the equation (3). Electric field is then calculated by vector superposition of magnitudes of various directional components. Electric field intensity as a result of charge simulation methods can be calculated by Eq.4.

$$\vec{E} = -\nabla V \ \text{(V/m)} \qquad (4)$$

2.2. Biot-Savart Laws

Magnetic field variation calculated by using Biot Savart's rule is time dependent current variation. Fig.1 demonstrates the geometry of transmission lines for magnetic field calculation.

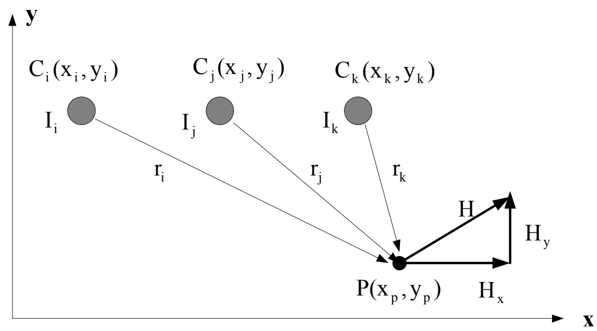

Fig.1. Magnetic field calculation for three conductor's lines

Distance between $P(x_p,y_p)$ and (x_i,y_i) conductor location is given by Eq.5.

$$r_i = \sqrt{(x_p - x_i)^2 + (y_p - y_i)^2} \qquad (5)$$

Components of magnetic field at $P(x_p,y_p)$ are given by Eq.6 and Eq.7.

$$H_{xi} = \frac{I_i}{2\pi} \frac{y_p - y_i}{r_i^2} \qquad (6)$$

$$H_{yi} = \frac{I_i}{2\pi} \frac{x_p - x_i}{r_i^2} \qquad (7)$$

X-component of magnetic field is parallel to ground and perpendicular to the conductor and y component is perpendicular. Total observed magnetic field at any location is given by Eq.8.

$$H = \sqrt{\left(\sum_{i=1}^{n} H_{xi}\right)^2 + \left(\sum_{i=1}^{n} H_{yi}\right)^2} \qquad (8)$$

and magnetic field density is given by Eq.9. [26].

$$\mathbf{B} = \mu_0 \mathbf{H} \qquad (9)$$

where $\mu_0 = 4\pi 10^{-7}$ H/m.

3. ELECTRIC AND MAGNETIC FIELD LEVELS IN RESIDENTIAL AREAS

The analysis for electric and magnetic field variations in residential area based on 34.5kV and 31.5kV power lines have been preferred, since a distance between MV-PDL and buildings were measured between 5 to 12m as shown in Fig.2. Potential of power lines and charge loads have been taken into consideration during analysis. During the analysis, potential altitude (h) and perpendicular distance variation to power lines have also been investigated. This approach lets us to calculate both vertical and horizontal electric and magnetic field distance variation.

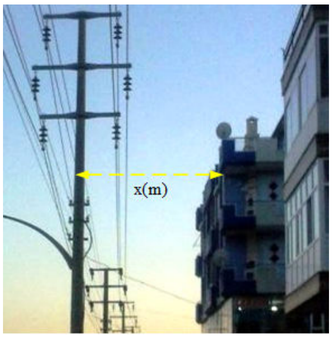

Fig. 2 Typical MV-PDL passing through in residential areas.

Fig.3 shows an increase of electric field intensity variation depending on both x and y direction. It is obtained that electric field intensities are merging at 10m of distance from power lines at different altitudes. At a distance of 3m altitude(1st floor apartment) reads about 0.42kV/m and 6m altitude (second floor apartment) reads 0.75kV/m which about 2 times higher than first floor.

Fig.4, Fig.5 and Fig.6 show an increase of magnetic field intensity variation depending on both x and y direction as a result of load current. Upper apartments have more risks then basements. Magnetic field intensities are merging at 10m of distance from power lines at different altitudes as electric fields.

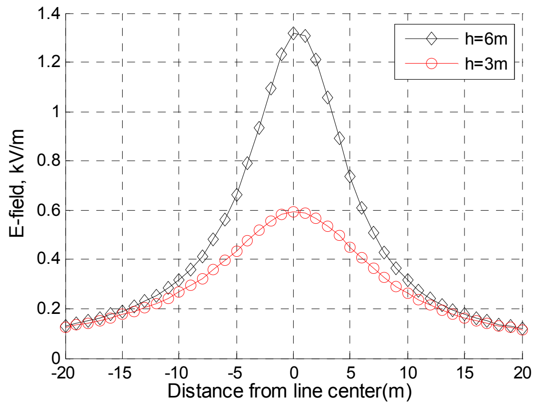

Fig. 3 EF variation depending on altitude for 34.5 kV MV-DPL.

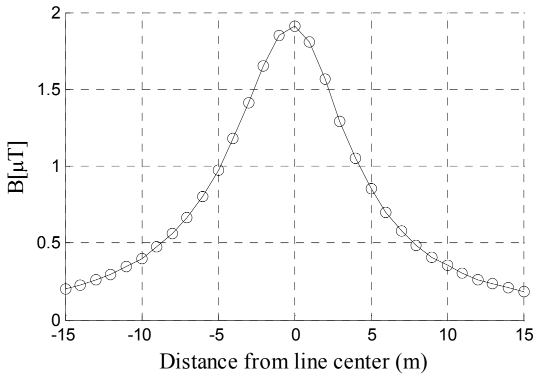

Fig.4.Magnetic field variation depending distance from line center at 3m height for 100A load current (34. 5kV MV-PDL).

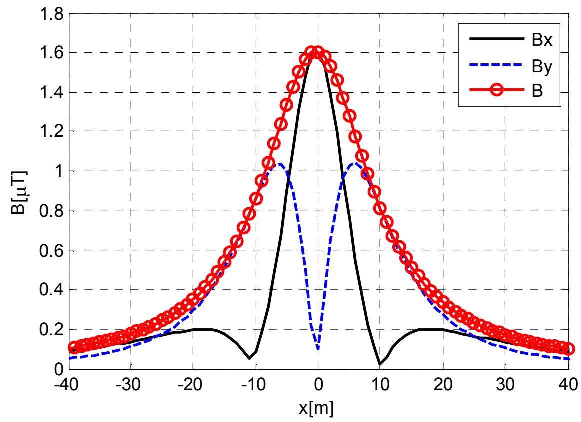

Fig. 5 MF variation at 1m height (31.5 kV MV-PDL with double circuits)

Fig.5 shows x and y components of magnetic field variation depending on distance from line center. It is observed that x component is dominant closer than 5m, and y component becomes dominant after 5m distance. Both x and y components are merging after about 30m distance. 18m of band refers to the child leukemia risks which are equal and greater than 0.4μT. The first circuit of 31.5kV PDL current is driving 226.6A and second circuit current is driving 112A.

In this study, a real data obtained from regional power distribution company named Akdeniz EDAS was used in order to calculate both magnetic and electric fields around lines. There is seasonal variation on current loads on power lines as expected; peak load values are obtained in August in summer season and December and January in winter season. Those are critical time durations. Fig.6 and Fig.7 demonstrate monthly-based current distributions on power lines and their resultant field levels. As expected, magnetic and electric field variations around power lines are changing by season with respect to driven current on the line.

Fig.6 demonstrates monthly-based load variation during a year for first sample of 31.5kV MV-PDL, and produced magnetic field levels at 1m heights and under the line. August reads higher power demand as well as magnetic fields. Fig.7 demonstrates monthly-based load variation during a year for 31.5kV MV-PDL, and produced magnetic field levels at 1m heights and under the line. January reads higher loads as well as magnetic fields.

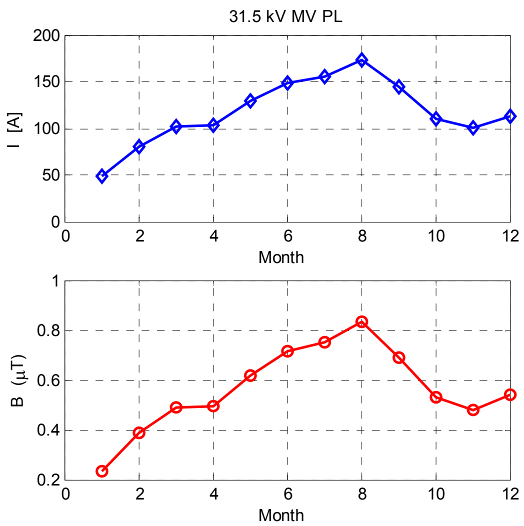

Fig. 6 Monthly based current load variation and magnetic field density for 31.5 kV MV-PDL.

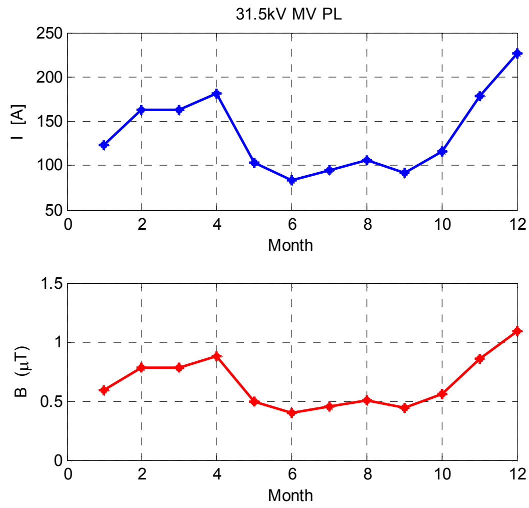

Fig. 7 Monthly based current load variation and magnetic flux for 31.5 kV MV-PDL.

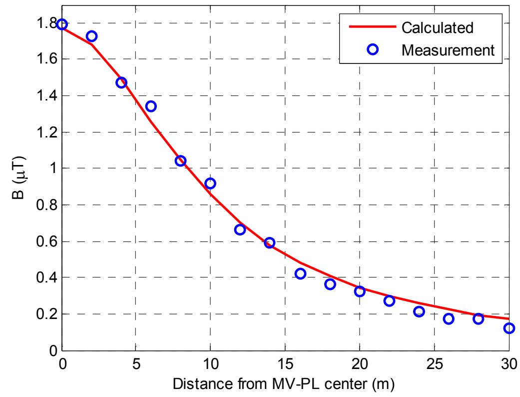

Fig. 8 Magnetic field variation form distance line center (at 1.5m height)

Fig.8 depicts the magnetic field variation from distance line center of 31.5 kV MV double circuits power line. The magnetic field have been predicted by analytically and measurement. The measurement has been performed by using HIOKI- HITESTER 3470 magnetic field meter with a type 3471 field probe (10Hz-400 kHz). During the actual magnetic field measurement, the first circuit of 31.5kV MV-PDL current is driving 220A and second circuit current is 110A, and the calculation has been made for this currents. The results show that the good compatible with measured and predicted magnetic field levels.

4. CONCLUSIONS

Medium voltage power lines established in the residential area close to the apartments have been investigated in this study. Less than 10m distance to the buildings has potential for child leukemia, since magnetic field levels are around 0.4 μT and up. It has been observed that any selected safety distance cannot be a safe for upper apartments at the same building. From electric field intensity point of view, there seems no critical electric field level at 50Hz, and still there is dramatic increase from basement to upper apartments.

These results require electric distribution companies and governments to take into consideration of safety distances in electric and magnetic field point of view. There need to be new standards to be defined especially sensitive groups such as child and pregnant, since there is a big difference between standards and scientific reports [12-17]. Limits should be set at 0.2µT and less, and underground power lines, shielding technique for critical building should be preferred for better public safety.

It is offered that electric distribution companies should predict seasonal magnetic field variations for expected loads for safety concerns and inform people during that time duration, and independent authorized organizations such as universities have to make random cross check measurements.

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