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LEVELS OF EXTREMELY LOW-FREQUENCY ELECTRIC AND MAGNETIC FIELDS FROM OVERHEAD POWER LINES IN THE OUTDOOR ENVIRONMENT OF RAMALLAH CITY-PALESTINE

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In this study, levels of extremely low-frequency electric and magnetic fields originated from overhead power lines were investigated in the outdoor environment in Ramallah city, Palestine. Spot measurements were applied to record fields intensities over 6-min period. The Spectrum Analyzer NF-5035 was used to perform measurements at 1 m above ground level and directly underneath 40 randomly selected power lines distributed fairly within the city. Levels of electric fields varied depending on the line's category (power line, transformer or distributor), a minimum mean electric field of 3.9 V/m was found under a distributor line, and a maximum of 769.4 V/m under a high-voltage power line (66 kV). However, results of electric fields showed a log-normal distribution with the geometric mean and the geometric standard deviation of 35.9 and 2.8 V/m, respectively. Magnetic fields measured at power lines, on contrast, were not log-normally distributed; the minimum and maximum mean magnetic fields under power lines were 0.89 and 3.5 μT, respectively. As a result, none of the measured fields exceeded the ICNIRP's guidelines recommended for general public exposures to extremely low-frequency fields.

INTRODUCTION

Wherever electricity exists, there exist, as well, electric and magnetic fields. Electric fields arise from electric charges (i.e. potential difference) and are shielded by most common materials, even the human body[(1)]. Magnetic fields, on the other hand, originate from the motion of electric charges (i.e. currents) and can easily penetrate most materials[(1)]. Electric power operates at a frequency of 50 or 60 Hz[(2)] (50 Hz in Palestine)[(3)], this frequency belongs to the range (3–3000 Hz) usually named as extremely low frequency (ELF). Both electric and magnetic fields originated from power frequency are called extremely low frequency electric and magnetic fields (ELF EMF)[(2)].

Transmission lines, high-voltage (HV) power lines and transformers, and distributors are major sources of ELF EMF[(4)]. The huge demand for electricity in the modern life, resulted in extending HV power lines in rural, sub-urban, urban areas and sometimes in close vicinity to populated areas, and substantially increasing the public exposure to ELF EMF. However, electric and magnetic fields underneath a power line vary depending on the voltage and the current carried by the line[(5)].

Over time, there have been much concerns about ELF magnetic fields and its potential to assist health risks as childhood leukemia, breast cancer and other symptoms that might be attributed to long term exposure to this field[(6–12)].

The public concern regarding the possible health implications of exposure to ELF fields in Palestine has underlined the importance of having accessible and easy to recognize information about ambient levels of ELF EMF in our environment. And here the results obtained by a study on levels of ELF fields from power lines in Ramallah city.

MATERIALS AND METHODS

Study area

Ramallah City, where the study measurements were carried, is a Palestinian city in the center of the west bank to the north of Jerusalem, with an average elevation of 880 m above sea level[(13)]. The study was mainly focused on ELF fields from overhead power lines in the environment of Ramallah, a group of 40 randomly selected power lines in different areas inside the city were under investigations of ELF EMF levels. The lines were categorized into HV power lines and HV transformers with voltage of 66 or 33 KV, along with some typical low-voltage distribution lines. The 40 power lines, under which measurements were carried out during autumn of 2016 (September through November) were fairly distributed in the city environmental locations:

Al-Irsal, Al-Balo', Al-Masayef, Al-Tirah, Bitonia, Sateh-Marhaba, Al-Birah, Al-Masyoun, Ein-Menjed and Ein-Mesbah (Figure 1).

Data collecting

Fields measurements were performed with the Spectrum Analyzer NF-5035 from Aaronia with an accuracy of 3%. Comprising a three-dimensional antenna for magnetic field measurements is one important feature of this spectran[14]. A laser distance meter (HILTI)[15] was used to adjust distances and a GPS devise (hp iPAQ)[16] to record the coordinates of power lines. Measurements were taken directly underneath the line and at one meter[17] above the ground level. Variations of ELF fields were recorded over 6-min period for both electric and magnetic fields separately.

The data recorded from different measurements carried under power lines were tested with Minitab 17 software[18] to carry out the ranges, arithmetic means and standard deviations (SD) of ELF fields. For fields distributions, the probability density functions, geometric means and geometric standard deviations were also calculated[19, 20].

RESULTS

Ranges of ELF fields measured at power lines locations, arithmetic means (AM) and SD are summarized in Table 1.

The analysis of data showed a log-normal distribution for ELF electric fields from power lines with geometric mean, geometric SD and median of 35.9, 2.8 and 34.8 V/m, respectively (Figures 2 and 3). While, on the other hand, magnetic fields were not log-normally distributed.

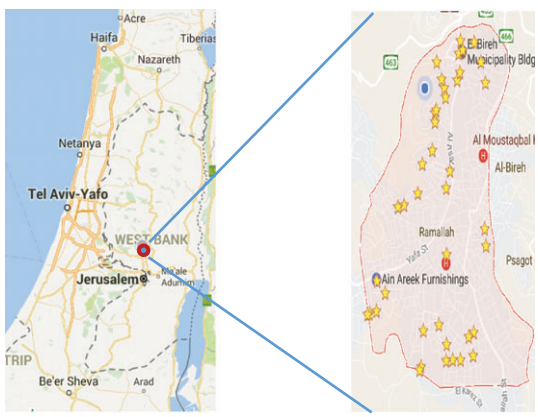

Figure 1. A map of Palestine showing the city of Ramallah in the west bank (left), and a magnified map of the study area showing locations of the 40 power lines (right).

DISCUSSION AND CONCLUSIONS

ELF magnetic fields from power lines

No significant divergence was noticed in the ELF magnetic field intensities measured at power lines. The highest and lowest means 3.5 and 0.9 μT were found at power lines P1 and P13, respectively. Electric current and electricity load at the instance of measurement might be two possible justifications for the

Table 1. Ranges, arithmetic means and standard deviations of ELF fields measured at power lines.

E-field (V/m)				B-field (μT)		
Power line	Range[a]	AM	SD	Range[a]	AM	SD
P1	5.8–45.1	20.5	11.8	3.3–3.6	3.5	0.11
P2	1.5–2.9	2.6	0.7	2.5–2.9	2.8	0.16
P3	15.3–60.6	40.7	11.6	1.7–3.1	2.5	0.5
P4	21.3–35.2	27.7	4.5	2.8–3.0	2.9	0.05
P5	26.7–43.5	39.3	4.6	2.3–3.4	2.8	0.4
P6	51.0–71.0	65	5.7	2.0–3.2	2.8	0.4
P7	20.9–27.1	25.0	1.9	2.7–2.9	2.9	0.08
P8	29.3–44.6	38.8	6.2	2.9–3.0	2.9	0.03
P9	32.8–47.1	37.9	4.0	2.9–3.0	2.9	0.03
P10	4.5–8.6	6.6	1.3	2.2–2.9	2.7	0.2
P11	37–56.7	45.6	5.3	1.8–3.2	2.6	0.4
P12	61–110.8	75.3	16.9	2.6–3.0	2.8	0.1
P13	12.3–17.8	15.0	1.6	0.8–0.9	0.9	0.06
P14	33.4–39	36.3	2.0	2.2–3.0	2.9	0.22
P15	115.5–136.9	130.5	6.2	1.7–3.0	2.8	0.4
P16	21.1–28.9	25.6	2.5	2.8–3.0	2.9	0.07
P17	41.1–58.4	52.7	4.5	2.8–3.0	2.9	0.05
P18	49.2–57.9	52.7	2.3	2.8–3.0	2.9	0.09
P19	400–873.3	769.4	140.5	2.8–3.0	2.9	0.03
P20	21.2–25.9	23.4	1.7	2.7–3.0	2.9	0.06
P21	17.6–25.8	20.5	2.3	2.8–3.0	2.9	0.1
P22	12.1–17.9	14.9	1.8	2.8–3.0	2.9	0.06
P23	20.5–24.7	22.9	1.4	2.6–3.3	2.8	0.18
P24	85.3–110.7	104.1	6.9	2.7–3.0	2.9	0.1
P25	25–31.5	27.7	1.9	2.8–2.9	2.9	0.06
P26	22–27.2	24.4	1.7	2.8–3.0	2.9	0.06
P27	7.6–10.9	9.4	1.2	2.3–3.0	2.7	0.24
P28	24.3–28.5	26.6	1.4	2.7–2.9	2.8	0.1
P29	58.8–65.4	61.7	2.0	2.8–3.0	2.9	0.08
P30	186.3–222.1	202.8	9.9	2.4–3.0	2.8	0.15
P31	48.2–107	65.7	20.3	2.7–2.91	2.8	0.1
P32	21.1–23.7	22.5	0.8	3.4–3.7	3.5	0.1
P33	3.6–5.4	4.4	0.5	3.4–3.7	3.5	0.09
P34	18.7–24	20.7	1.7	2.7–3.0	2.9	0.1
P35	23.8–34.3	28.2	3.2	2.8–3.0	2.9	0.05
P36	51–66.8	58.4	4.0	2.8–3.0	2.9	0.06
P37	5.9–12.2	9.4	2.0	2.6–3.0	2.9	0.13
P38	37.9–54.6	46.4	5.9	1.7–2.4	2.2	0.2
P39	11.99–19.7	16.7	2.3	2.7–2.9	2.8	0.1
P40	0.7–5.8	3.9	1.5	2.7–3.0	2.9	0.1

[a]The range shows the minimum and maximum recorded fields.

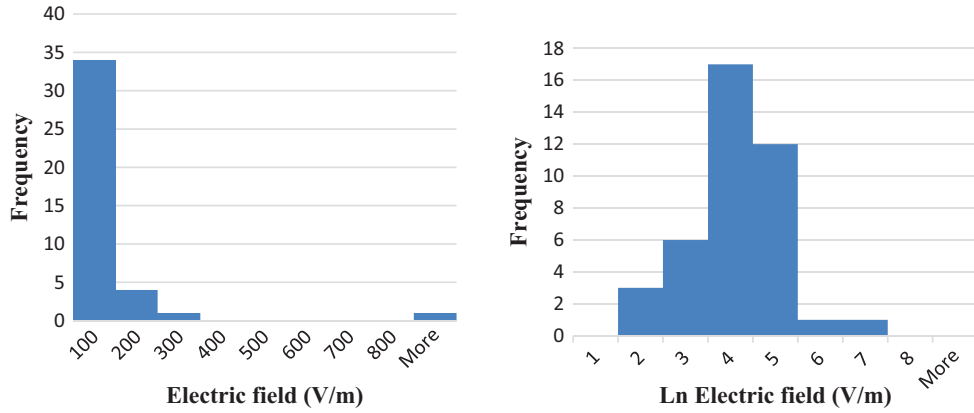

Figure 2. A histogram of ELF electric fields (left) and ln of ELF electric fields (right) based on maximum recorded intensities at the 40 power lines.

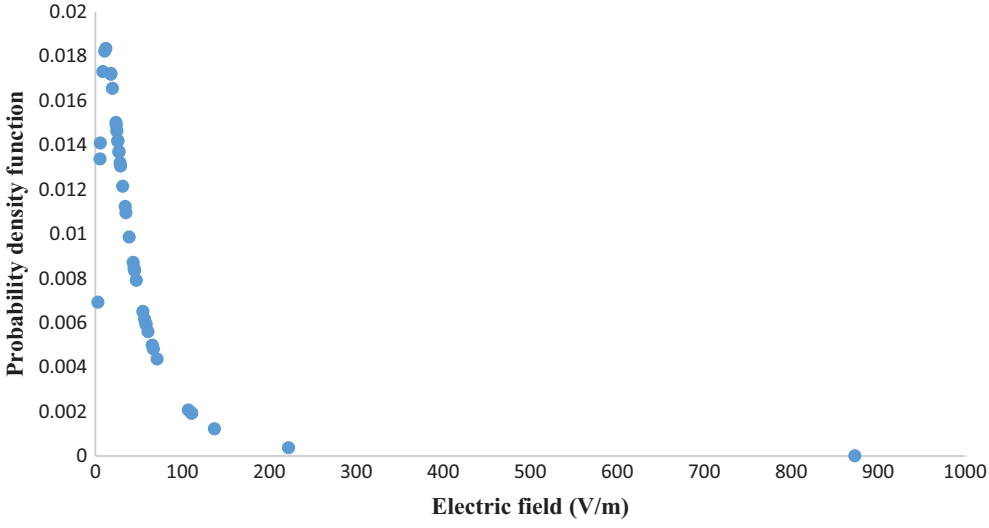

Figure 3. The log-normal distribution of maximum recorded ELF electric fields from the 40 power lines (based on the values of parameters is $\mu = 358$ V/m and $\sigma = 1.03$ V/m).

Table 2. Reference levels for exposure to time-varying EMF for frequencies up to 800 Hz.

Frequency range	E-field (V/m)	B-field (μT)
1–8 Hz	10 000	$4 \times 10^4/f^2$
8–25 Hz	10 000	$5000/f$
0.025–0.8 kHz	$250/f$[a]	$5/f$

[a]f is the frequency as indicated in the frequency range.

gap between these two readings. However, the rest of power lines experienced approaching means of magnetic fields within the range 2.2–3.5 μT.

ELF electric fields from power lines

For ELF electric fields, on contrast, an obvious variation of field's intensities was noticed amongst different power lines. The lowest means 3.9, 4.4, 9.3, 9.4, 14.9, 16.7 and 22.5 V/m belonging to the power lines

categorized as distributors, where low-voltage electricity is carried.

Likewise, the highest means 769.4, 202.8, 130.5 and 104.1 V/m are compatible with the lines category, under which these fields were measured as HV power lines.

Both magnetic and electric field strengths from power lines distributed in the environmental areas of the City Ramallah were well below the ICNIRP's limits[21] (Table 2).

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