Investigation of Extremely Low Frequency Magnetic Field (ELF-MF) Flux Densities in the Vicinity of Schools in Tehran

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Abstract: Epidemiologic studies have shown the relation between exposure to extremely low frequency magnetic fields (ELF-MFs) and childhood leukemia, so assessment of children exposure levels in different environments is considered as a serious precedence. Present study aimed at determining ELF-MFs flux densities near schools in Tehran. Measurements were performed near randomly selected schools in three different periods of time (i.e. 6-9 PM, 9-12 AM and 12-3 AM) using HI-3604 Power Frequency Field Strength Measurement System according to IEEE standard procedure. Data analysis was done using ANOVA test. Mean, maximum and minimum ELF-MFs flux density were 0.147±0.08 µT, 0.6130 µT and 0.0237 µT, respectively. There was no significant difference neither among different periods of time nor among different schools located at different parts of the city. According to the results from this study, although ELF-MFs flux density in Tehran’s schools is significantly lower than ICNIRP guidelines (0.15%), one third of cases still exceed the value of 0.2 µT, which is considered as a baseline for increased risk of childhood leukemia. In addition, since magnetic flux density rapidly decreases as the distance from the source increases, its spatio-temporal variations can not be observed in locations far from the sources. For the same reason, exposure of schoolchildren to ELF-MFs in Tehran’s schools is only considerable in long-term aspect. Results of present study can be used for computation of schoolchildren’s total exposure to ELF-MFs in different environments.

Key words: Magnetic fields • Extremely Low Frequency • Childhood leukemia • Exposure assessment

INTRODUCTION

In the past three decades, many studies have been performed on the health impacts of extremely low frequencies magnetic fields (ELF-MFs) from power distribution lines and electric appliances, most of which have resulted in contradictory findings [1-9]. This is mainly due to the fact that quite different exposure levels are assessed by different studies. Nevertheless, there is an agreement on the impact of ELF-MFs on childhood leukemia [10-14]. Hence, it can be concluded that there is a high priority for assessment of children exposure levels to ELF-MFs. Thus, different studies have measured ELF-MFs flux densities at homes [15-17] and in bedrooms [18], as well as children exposure to ELF-MFs produced from television sets used for either watching TV programs or playing video games [19]. Mezei et al. [20] stated that ELF-MFs exposure is not limited to a special environment. For calculation of total exposure of a person, therefore, it is quite necessary to consider all exposures in all environments.
in which a person might be present. As children and adolescents spent most of their daytime in schools, determination of ELF-MFs exposure level in this environment as well as its proportion in the total exposure level seem to be of considerable importance. In this field, however, few studies have been performed in recent years [21-22], results of which were quite different because the distance between measurement points and ELF-MFs sources were not the same. In addition, the impact of power consumption fluctuations was not considered in either of the studies.

The aim of the present study was to determine ELF-MFs flux densities near schools in Tehran during three different periods of time, including 9-12 AM, 6-9 PM and 12-3 AM. We also set out to consider the impact of power consumption fluctuation on magnetic field flux density and to compare the results with available standards [23]. Results of this study can be used to estimate total exposure level of sensitive groups to ELF-MFs in all environments.

MATERIALS AND METHODS

Tehran, the capital of Iran, with total population of 9 million, is considered as one of the largest megacities in the world and located at 51° 8' to 51° 37' N to 35° 34' to 35° 50' E. In this city, there are high voltage power transmission and distribution lines passing though distinct areas, in addition to middle voltage power lines (frequency approximately between 40 and 60 Hz) running through any streets and avenues by the light poles at height of 10 m. Tehran has 7000 educational centers (kindergarten to high school). To obtain the required number of measurements points, 30 educational centers as a pilot were considered. According to the very low standard deviation of ELF-MFs flux densities in these 30 centers, it was found that these samples were sufficient to be representative of whole educational centers. In addition, measurements were performed in 30 educational centers to obtain a reliable average ELF-magnetic flux density. Selection of these centers was performed randomly using SPSS software Ver. 15. Figure 1 illustrates the location of the education centers in Tehran. Locations of power stations as well as high-voltage power transmission lines are also specified in this map. Note that the centers were classified into 5 groups according to their geographical locations, 1) Central; 2) Northern; 3) Eastern; 4) Southern; and 5) Western, to provide a better understanding of ELF-magnetic field exposure in different areas of the city.

To measure ELF-MFs flux densities, HI-3604 Power Frequency Field Strength Measurement System was used. This meter is used to measure ELF-MFs flux densities from power transmission and distribution lines along with electrically operated equipment and appliances. When the system is placed in an alternating magnetic field, a current is induced in the coil which is proportional to the strength of the applied magnetic field. This meter is designed to measure the magnetic fields in the range of 0.1 mG-20 G [24].

In this study, measurement method was based on IEEE standard procedures (Std 644-1994) for measurement of ELF-MFs flux density [25]. Based on this guideline, the whole measurements were performed at the height of 1 m above the ground. Considering the aim of this study which was assessment of the of children exposure level to ELF-MFs, all the measurements were done in front of school entrances to make a harmony in measurements. It is noteworthy that HI-3604 meter measures ELF-magnetic flux density only in one single vector. Therefore, the following equation was used for calculation of the resultant magnetic field [25]:

\[ B = \sqrt{B_x^2 + B_y^2} \]

Fig. 1: Location of the sampling sites as well as high-voltage power distribution lines across the city
\[ B_R = \sqrt{B_{\text{max}} + B_{\text{min}}} \]  

Since magnetic flux density depends on the electric current inside power transmission lines and the power consumption fluctuates during daytime, three different periods of time were selected for data collection to consider possible impact of time on magnetic flux density: 6-9 PM as the maximum power consumption period; 12-3 AM as the minimum power consumption period; and 9-12 AM as the average power consumption period. In addition, because of the effects of meteorological parameters such as temperature, rain fall, humid, etc. on ELF-MFs flux density, all the measurements were carried out in one season (i.e. winter) and in the same weather conditions (i.e. sunny days and a clear sky with out any clouds during night), so that it is not influenced by variations in weather conditions.

Finally, data analyses were performed using ANOVA test in SPSS software (version 15). Significance level was \( P < 0.05 \).

### RESULTS

Table 1 presents the ELF-MFs statistics in five different groups of schools in Tehran (north, east, south, west and central) during different periods of time.

<table>
<thead>
<tr>
<th>School Classification</th>
<th>Periods of time</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>9-12 AM</td>
<td>0.0462</td>
<td>0.3968</td>
<td>0.1303</td>
<td>0.1062</td>
</tr>
<tr>
<td></td>
<td>6-9 PM</td>
<td>0.0312</td>
<td>0.3256</td>
<td>0.1150</td>
<td>0.1170</td>
</tr>
<tr>
<td></td>
<td>0-3 AM</td>
<td>0.0375</td>
<td>0.3549</td>
<td>0.1208</td>
<td>0.1124</td>
</tr>
<tr>
<td>Western</td>
<td>9-12 AM</td>
<td>0.0237</td>
<td>0.2954</td>
<td>0.1091</td>
<td>0.0825</td>
</tr>
<tr>
<td></td>
<td>6-9 PM</td>
<td>0.0375</td>
<td>0.4178</td>
<td>0.1345</td>
<td>0.0925</td>
</tr>
<tr>
<td></td>
<td>0-3 AM</td>
<td>0.0345</td>
<td>0.3163</td>
<td>0.1078</td>
<td>0.0798</td>
</tr>
<tr>
<td>Northern</td>
<td>9-12 AM</td>
<td>0.0302</td>
<td>0.6130</td>
<td>0.1730</td>
<td>0.0890</td>
</tr>
<tr>
<td></td>
<td>6-9 PM</td>
<td>0.0350</td>
<td>0.4813</td>
<td>0.1482</td>
<td>0.0891</td>
</tr>
<tr>
<td></td>
<td>0-3 AM</td>
<td>0.0437</td>
<td>0.3987</td>
<td>0.1365</td>
<td>0.0839</td>
</tr>
<tr>
<td>Southern</td>
<td>9-12 AM</td>
<td>0.0400</td>
<td>0.3541</td>
<td>0.1293</td>
<td>0.0768</td>
</tr>
<tr>
<td></td>
<td>6-9 PM</td>
<td>0.0775</td>
<td>0.4450</td>
<td>0.1497</td>
<td>0.0645</td>
</tr>
<tr>
<td></td>
<td>0-3 AM</td>
<td>0.0500</td>
<td>0.5360</td>
<td>0.1597</td>
<td>0.0722</td>
</tr>
<tr>
<td>Eastern</td>
<td>9-12 AM</td>
<td>0.0300</td>
<td>0.5840</td>
<td>0.1821</td>
<td>0.0835</td>
</tr>
<tr>
<td></td>
<td>6-9 PM</td>
<td>0.0375</td>
<td>0.5995</td>
<td>0.1747</td>
<td>0.0850</td>
</tr>
<tr>
<td></td>
<td>0-3 AM</td>
<td>0.0325</td>
<td>0.5570</td>
<td>0.1641</td>
<td>0.0870</td>
</tr>
</tbody>
</table>

The total mean value of ELF-MFs flux density was 0.147±0.08 \( \mu \text{T} \) and the minimum and maximum values were 0.0237 and 0.6130 \( \mu \text{T} \), respectively. It can be observed that the mean, min and max of ELF-MFs flux density in Tehran’s schools were only 0.15%, 0.023% and 0.6% of the ICNIRP guidelines [23], respectively, which are quite negligible.

According to ANOVA test for five different groups of schools, there was no significant difference in the ELF-MFs flux densities among the schools located at different areas in Tehran (\( P < 0.05 \)). Furthermore, to evaluate the effect of height on the ELF magnetic field flux density, a separate test was conducted for schools placed in north and south of Tehran (Note that there is a great height difference between the north and south of Tehran), which produced no significant result (\( P < 0.05 \)). In fact, the effect of height on ELF-MFs flux density is not considerable in this scale. In addition, no statistically significant difference was perceived in ELF-MFs flux densities over different periods of time (\( P < 0.05 \)).

According to the range of data, ELF-MFs flux densities were classified into three categories and the number of measurements laid in each category was calculated as a percentage of the total and the results were summarized in Table 2. As shown in this Table, ELF-MFs flux densities in all schools were lower than 1 \( \mu \text{T} \).
(only 1% of ICNIRP guidelines). According to the epidemiologic studies performed on the ELF-MFs exposure and childhood leukemia, however, the value of 0.2 µT is considered as the baseline risk which means 33.5% of measurements exceeded the limit and are, therefore, of great importance.

**DISCUSSION**

Although it was anticipated a change in the ELF-MFs flux density is observed as a result of fluctuations in power consumption over different hours of the day, no significant difference was observed. The results of this survey are in agreement with the findings of Lin [21] who investigate ELF-MFs exposure level of schools situated in close proximity to high-voltage power lines (exposed groups) as well as those far away from such sources (non-exposed groups). It was shown that the standard deviations were higher in the exposed group compared to those of the non-exposed group which may be related to the hourly fluctuations in electricity loading of the power lines, as well as the rapid reduction of magnetic field flux density with distance from the source. In fact, in the schools located near high-voltage power distribution or transmission lines, effect of power consumption fluctuations on ELF-MFs flux densities could be easily observed. In the schools located far from such sources, however, ELF-MFs flux densities are too low, so that variations of magnetic flux density in different periods of time were not significant.

It was also stated in above study that in those campuses situated far away from high-voltage power lines (non-exposed groups), mean ELF-MFs exposure level was 0.14 µT and only 10.9% of schools exceeded the baseline value of 0.3 µT, whereas mean ELF-MFs flux density for exposed groups was 0.38 µT and about 39.8% of the measurements exceeded 0.3 µT. In this study, similarly, mean magnetic field flux density was 0.147 µT owing to the far distance from the ELF-MFs sources.

No statistically significant difference in ELF-MFs flux densities was observed among different groups of schools in Tehran, which is quite consistent with the study conducted by Tardon [22]. In this study, which was conducted in Oviedo, Barcelona Province, ELF-MFs flux densities were measured in four predefined points at schools, including classrooms, canteen, playground and entrance of the schools. It was shown that the average exposure in Barcelona was higher than that in Oviedo. This is probably because Barcelona is a more industrialized area, having much denser power distribution and transmission lines and a higher population density. Thus, a significant difference was observed in ELF-MFs flux density at schools in Barcelona, while as ELF-MFs flux density was totally lower in Oviedo, no statistically significant difference was perceived at schools in Oviedo. The results of this study also indicated that as the distance from ELF-MFs sources increases, magnetic flux density decreases rapidly, so that no statistically significant difference can be observed in place and time. In addition, since the strong sources of ELF-MFs evaluated in this study were far away from high-voltage power distribution and transmission lines or transformer stations, no significant difference in magnetic field flux density was recorded among different groups of schools. The only noticeable magnetic field source adjacent to schools in Tehran was middle-voltage power lines which had appropriate distances from the schools.

According to the results from present study, mean ELF-MF flux density near schools in Tehran is much lower than ICNIRP guidelines (about 0.15% of ICNIRP values). However, when considering the value of 0.2 µT which is considered in epidemiologic studies as a baseline for increased risk of childhood leukemia [26], it can be concluded that ELF-MFs exposure is still an important issue for children and should by no means be neglected. According to Maezi [20], on the other hand, all the other environments in which children might be exposed to ELF-MFs should also be taken into consider. One of the most important environments for children exposure to ELF-MFs is houses which has been the subject for many studies [15-17]. Comparing the results from present study with those from above studies, it can be concluded that houses contribute the most to the total exposure to ELF-MFs, especially when high-voltage power distribution and transmission lines or transformer stations exist near them. This is mainly because children spend most of their time in house. However, it should not be led to neglecting contributions of other environments to total exposure, especially that of houses.

A considerable body of evidence now exists that supports the effects of ELF-MF on human health, especially children. Hopefully, ELF-MFs flux density in environments in which children might be present is much lower than standard level for short-term exposure. In some areas, however, that ELF-MFs flux density exceeds baseline value of 0.2 µT, long-term exposure can be of considerable concern. Therefore, great attention should be paid and appropriate measures should be taken to
guarantee children health by evaluating exposure levels of children to ELF-MFs in different environments. Results of present study can be used for computation of schoolchildren’s total exposure to ELF-MFs in different environments.

ACKNOWLEDGEMENT

This work was supported by Iran Department of Environment.

REFERENCES


