DETERMINATION OF THE ELECTROMAGNETIC POLLUTION IN LOCAL SCHOOL INDOOR AND OUTDOOR ENVIRONMENTS

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Abstract: *This paper presents and analyses combining measurement of the RF and ELF bands of the EMF's from the external sources located around the 24 schools in Nilüfer / Bursa, TURKEY throughout 2013 – 2015. The study has been conducted in three steps. In the first step, a circular zone with constant diameter which take the school building as its center and might include base-stations and high-voltage transmission lines has been investigated. The number of EMF sources have been determined and they have been classified their source and band types. Then, in the second step, RF and ELF bands of the electromagnetic fields have been measured in different frequency bands. Then at the last stage, measurements at the some locations have been repeated and validation of the results have been checked. During measurements, Narda SRM 3006 spectrum analyzer, Narda NBM 550 broadband field meter and Narda ELT 400 survey meter have been used. Finally the measurement results have been provided in graphs and compared with the domestic and international exposure limits.*

Keywords: *Non-ionizing electromagnetic fields, electromagnetic field measurements, base stations, high-voltage transmission lines*

1. Introduction

Electromagnetic fields (EMFs) are important in today's environment, being inherent to communications, power and other needs of modern society. The proliferation in the use of Electromagnetic fields has been accompanied by an increased concern regarding their safety.

Electromagnetic fields exist wherever electric energy is generated, transmitted or used. Overhead lines produce both electric fields and magnetic fields. In Turkey, typical voltage for overhead power transmission lines may vary from 34.5 kV to 380 kV. Power frequency magnetic fields are receiving attention in recent years due to the concern that exposure to magnetic fields might cause health effects [1-3].

Epidemiological studies aim to establish possible links between exposures and adverse effects. Concern over extremely low frequency (ELF) fields has begun with a case control epidemiological study of childhood leukemia carried out by researchers. People living under or near transmission lines, or working in close proximity of mobile base stations' antennas are involved in the potential effects on human health of the EMF exposures [1]. Base station antennas are typically located in one antenna tower or few towers, which may be close to school buildings. Also power lines may pass over the school buildings in urban city. These stations have created unease feelings to the parents and teachers, that children may be affected by radiation from these electromagnetic sources.

Children may be more vulnerable to environmental toxins than adults. They may receive higher doses than adults either because of developing skulls of children, or because of their smaller body size. They may receive higher electromagnetic absorption from the exposure to EMF's than adults either because of water content of the bodies more than adults [4,5]. This raises the question of whether children are likely to be more sensitive than adults to Radio Frequency (RF) electromagnetic fields.

There are also indications that children may be more prone to leukemia stemming from the exposure to ELF magnetic fields. Electromagnetic fields exposure in schools can be examined from two kinds of sources: indoor and outdoor sources. Wiring, electrical appliances like computers, wireless systems are the basic indoor sources; whereas outdoor sources are mainly the transmission lines, substations, base stations, TV and radio transmitters near the schools. Evaluation of electromagnetic exposure in schools requires the determination of what kind of external sources exist and how far they are from the schools. [4-7]

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The location and effect levels of the sources should be selected to ensure that the electromagnetic field level in the environment is at a reliable level. In cases where the electromagnetic waves can not be reduced by the source, strengths of the electromagnetic fields, particularly in enclosed environments, can be reduced by attenuating using additional materials. By this process, which is defined as shielding, the input of the electromagnetic energy to the corresponding region is prevented to a great extent. For electromagnetic shielding, suitable materials with proper electrical parameters should be used [8-10].

This study has been conducted in primary schools in Bursa Nilüfer district, in Turkey. The study was established in three phases. In the first step, for each of the 24 schools, a circular zone with radius of 500m which take the school building as its center has been defined. The number of base station antennas and high voltage transmission lines detected in each particular circular zone are defined. After that, as the second phase, electric field levels have been measured the RF and ELF electromagnetic fields in the first zone of 20m radius. Then at the last stage, some measurements have been renewed for validation. All of the measurements in the primary schools are made to obtain accurate information and possible maximum risk about the exposure level of RF and ELF electromagnetic the fields.

2. EMF Guidelines and Exposure Limits

Safety requirements for confining exposure to EMF's are enforced by regulations. At the international level, safety guidelines for EM exposure have been issued by International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines on exposure limits for EMF's between the frequencies 0 Hz - 300 GHz .The ICNIRP limits are based on temperature rise exposed to human body [11]. American National Standards Institute (ANSI) operates for safety standards on EMF exposures. World Health Organization (WHO) and Federal Communication Commission (FCC) are some of the other regularity boards.

The ICNIRP guidance for EMF exposure which GSM base stations must satisfy changes between 41 V/m and 61 V/m depending on the operating frequency. Some countries as the Switzerland and Italy in sensitive areas applied lower limits from ICNIRP levels. The exposure limits in these countries based on precautionary concepts. The limit for the total EMF's from GSM base station antennas is 5 V/m in Switzerland [2,6,12].

In Turkey, The Information and Communication Technologies Authority (BTK) enforces the limits for the exposure to EMF. The regulations have been applied by the BTK in Turkey permits up to 45.25 V/m electric fields levels at indoor and outdoor areas [13,14]. Comparison of the maximum permissible EMF levels according to ICNIRP and BTK guidelines are illustrated in Fig. 1 and Fig. 2 for all spectrum presented in guidelines and a detailed view for GSM frequencies respectively.

Also a comparison of the maximum permissible total exposure limits at GSM frequencies among the reference levels of Turkey, Italy and Switzerland are listed in Table 1.

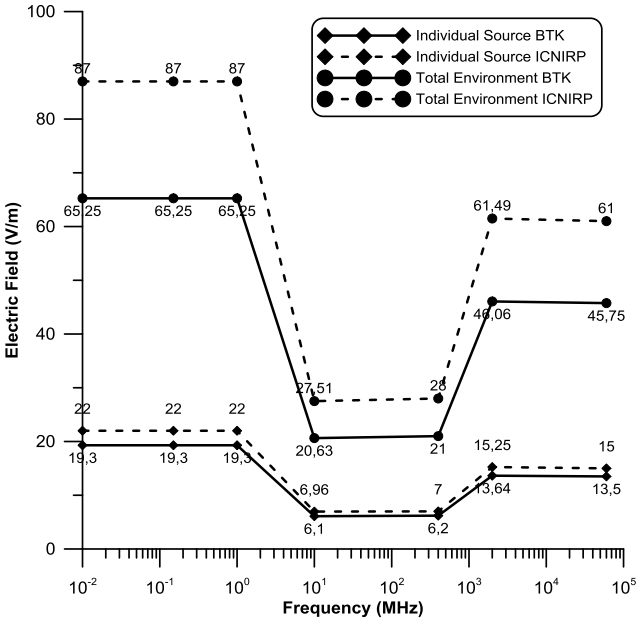

Figure 1. Comparison of the maximum permissible electric field values presented in BTK and ICNIRP guidelines

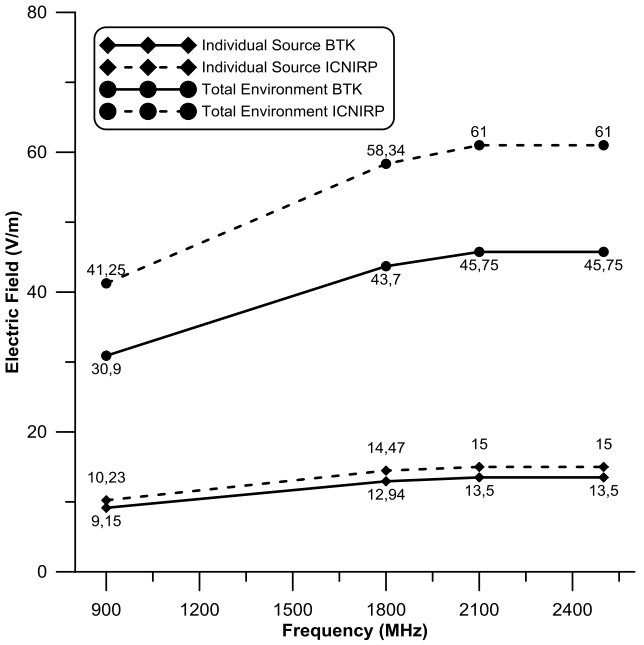

Figure 2. Comparison of the maximum permissible electric field values at GSM frequencies presented in BTK and ICNIRP guidelines

Table 1. Comparing the total exposure EMF reference levels of Turkey and some European countries

Country	GSM Band Maximum Permissible Electric Field Strength (V/m)
Turkey	45.25 (Total Environment) 13.5 (Each Individual Source)
Switzerland	5
Italy	6 (Total Environment)

3. Measurement Methodology

In this study, 24 schools have been selected according to community concern. Schools which have been involved in this study are in close proximity to main external sources of EMFs such as base station antennas, transmission lines and substations.

Measurement methodology used in the study are based on recommendations specified in standards and guidelines. According to BTK and ICNIRP guidelines, the exposure to RF electromagnetic fields is quantified in terms of electric field (V/m), magnetic field (A/m) and estimated power density (W/m2) measured that are the main components which have been assessed in this study. All RF radiation measurements arisen from base stations in the vicinity have been carried out in the far field. Measurements have been done between 10.00 am and 17.00 pm during day. All measurement points are selected a height about 1.5 meters above from the ground as the level of a thpical young person height. The duration of each measurement is determined as 6 minutes [13,14].

For the measurement of the electromagnetic fields radiated from mobile communication systems, two prime instruments have been used which are isotropic electromagnetic field meter (Narda NBM 550) and selective radiation meter (Narda SRM 3006). The other instruments are used for spreading of the different GSM frequencies. In the European standard [15], the evaluation approaches are divided into case A and case B. Case A provides a single result, covering all sources and frequencies. Case B provides a set of field values for sources, frequencies or frequency sub-bands. So the measuring study matched (compliance) the European standard.

Narda ELT 400 survey meter has been used for the measurement of the magnetic field exposures from transmission lines originated in each point.

For each of the 24 schools, a circular zone with radius of 500 meters are determined. Radiuses of the circles are determined by considering the border of the schoolyard [13,14]. The required information about the number of external sources exist in each zone were obtained from the department of Health-Environment Office of the Municipality of Nilüfer. This information also checked during the practical study. A map, illustration of schools for EMR measurement is shown in Figure 3.

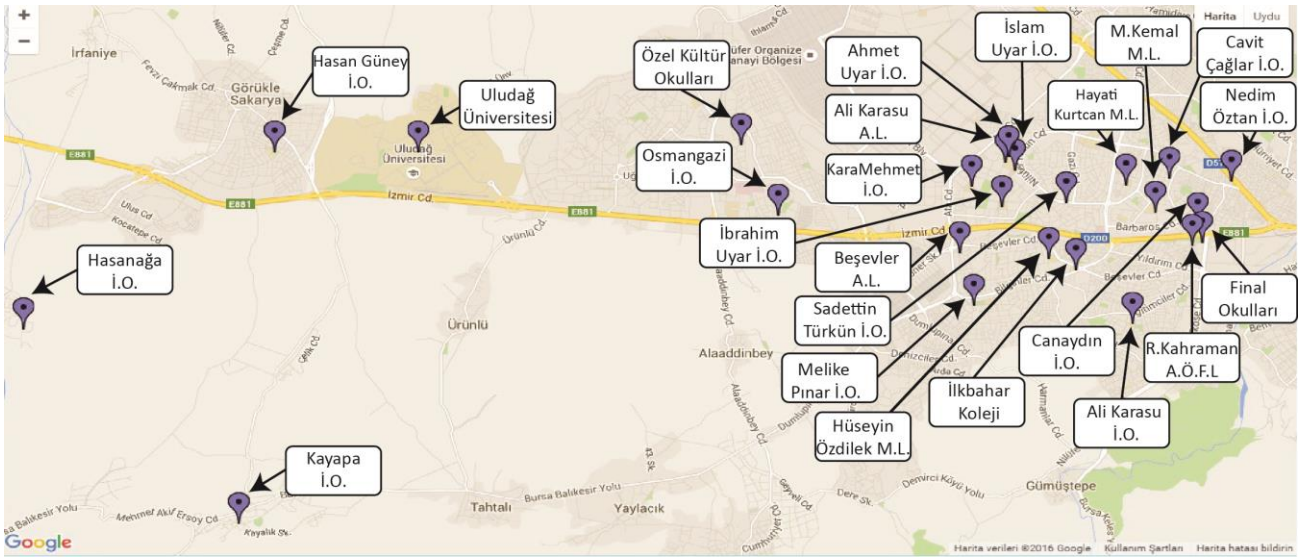

Figure 3. Determined schools for EMR measurements

Number of the sources determined for each particular schools are shown in Figure 4 and Figure 5 for GSM and ELF bands, respectively.

All of schools in the area have been named according to the measurement sequence as shown in the figures.

All of the spot measurements were carried out for both indoor and outdoor areas of the schools. During the indoor measurements, all electrical devices in the schools were switched off in order to determine the effects of ex-building sources. Electromagnetic field levels radiated from RF and ELF are measured separately using proper equipment. Numerous measurements have been carried out indoor and outdoor environment within the school boundaries and the maximum measured value has been recorded as the final result.

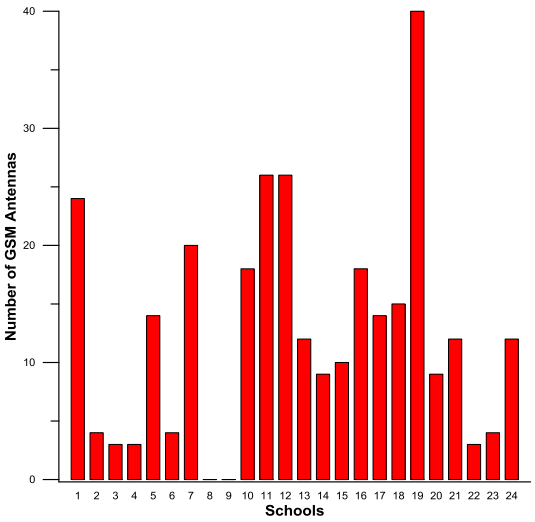

Figure 3. Number of GSM base antennas

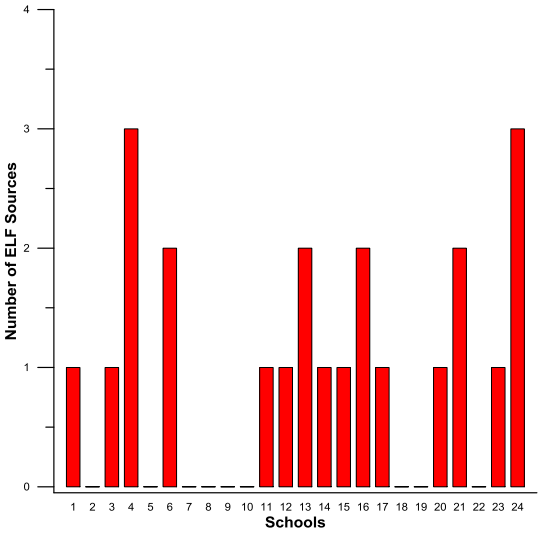

Figure 4. Number of electric power lines as the ELF band EMF sources

4. Measurement Results

Spot measurements have also been made within indoor and outdoor environment of the school buildings. Total electric field strength of each measurement packet and the total electric field strength for all measured frequency range are defined and shown in Figure 6.

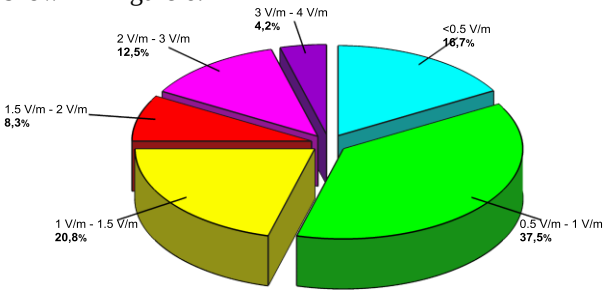

Figure 5. Percentage distribution of electric field levels at GSM frequencies

Overall magnetic field intensity for each measurement are considered and distribution values are shown in a pie chart form in Figure 7. As can be seen from the Figure 7, half of the magnetic field values measured in the school environments are below 0.5μT. About 5% of the measurements are above 4μT which are obtained usually near high-voltage lines.

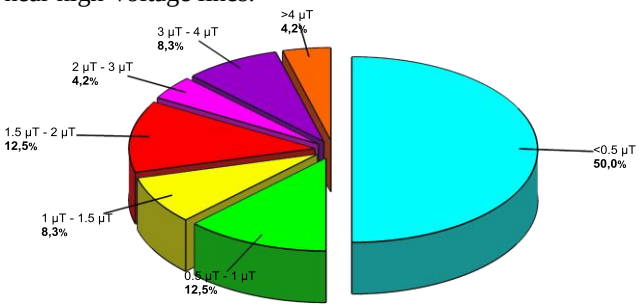

Figure 6. Percentage distribution of magnetic field levels at ELF

RF electromagnetic field values are measured in the frequency selective level by using the spectrum analyzer with isotropic electric field prob. Results are arisen especially around 900, 1800 and 2100 MHz which are currently used GSM mobile frequencies in Turkey. A typical frequency domain measurement result has depicted in Figure 8.

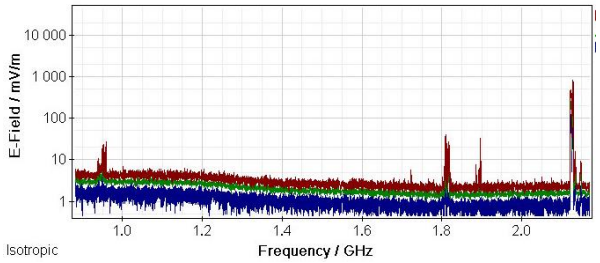

Figure 7. RF band electromagnetic radiation spectrum obtained from a school

Portion of total rate RF frequencies are shown in Figure 9. As can be seen from the figure that GSM frequencies are dominant and portion of other measurement packets at different frequencies are very low.

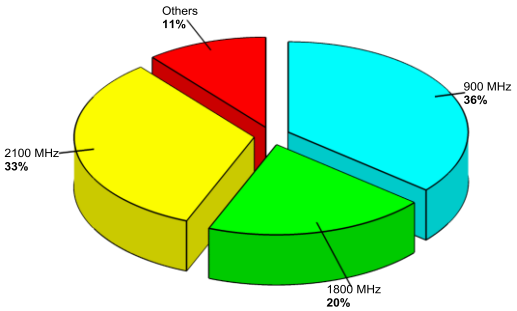

Figure 8. Total rate of over all electric field strengths at various RF and GSM frequencies,

5. Conclusions

In this paper measurement results of RF and ELF bands electromagnetic radiation arisen from the external sources located around the 24 schools in Nilüfer / Bursa, TURKEY obtained during 2013 – 2015 are presented. In the first step, a circular zone with a constant diameter taking the school building as its center is defined. In the second step the number of EMF sources are determined and classified their source and band types. Then, RF and ELF bands of the electromagnetic fields have been measured in different frequency bands. Measurement results have been provided various graphs and curves. They have been compared with the domestic and international exposure limits. The study also identified specific sources of the fields so as to determine the magnitude of EM exposure level at each particular source of ex-building for the schools in Turkey. From the results presented, following conclusions are derived:

For the RF EMF's levels in and out of the schools which are considered, it can be seen that field strengths are lower than the limits given by the BTK and ICNIRP guidelines. More than 45% of the schools, electric field strengths are higher than the average values of 1 (V/m).

At the areas of ex- buildings of the schools, the highest magnetic field strengths were measured at the schools with substations or which are near the power transmission lines. As the distance from the ex-building sources increases, the magnetic values decrease.

Only in 12 of the 24 schools considered, the magnetic field intensity is measured less than 0.5 μT. In the 15 of the schools, the magnetic field strengths exceed the 0.4 μT level above which ELF magnetic fields are associated with increased incidence of childhood leukemia [5,7]. However the incidence for a causal relationship is insufficient.

Children have constituently rights as well as adults, to have safe environment to learn play, thrive in school and home. Public policy makers therefore have a responsibility to provide a safe and healthy environment for all of us. Children spend a lot of their time at school and they are more sensitive to electromagnetic fields as compared to adults. They are still in the physiological and psychological development period. The nervous system has bioelectric properties that make it more susceptible to the effects of electromagnetic fields.

All RF and ELF EMF's levels measured in and out of the schools are below the limits presented by the BTK and ICNIRP guidelines. However, we recommend that EMF exposure should be kept as minimum as possible level in for "sensitive places". Therefore, we would suggest special exposure values in school areas. The reasonable and practically applicable suggestion of maximum electric field values is 1 V/m (covering GSM frequency) and maximum magnetic field levels is 0.5 μT for ELF bands for such sensitive places. Additionally, for some school buildings, antenna positions and directions should be reconsidered, and, if necessary, electromagnetic shielding measures should be taken into account.

Prudent avoidance risk policy might justify consideration of school location in sitting of high voltage electrical transmission lines or base station antennas and relocate either the EMF sources or schools. Reasonable preventive measures for the potential risk reduction must be adopted, in discussions of EMF hazards for children in school with help of experts in the field. The data presented in the paper represent useful knowledge for taking precautions and understanding the value of exposure in different environments of the schools and estimating the exposure levels.

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