MONITORING OF ELECTROMAGNETIC FIELDS IN AN URBAN SITE: PRELIMINARY RESULTS

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ABSTRACT

The sources of electromagnetic fields in the town of Brescia are broadcast transmitters installed outside the urban area, base transceiver stations, power lines and power stations within the town. The aim of this work is to analyse exposure levels from such sources in the general population. A map of the electromagnetic fields has been created starting from measurements of electric and magnetic fields at 38 points in the town. The choice of measuring sites, measuring method, time interval, the instruments is considered and discussed.

The results of this monitoring will provide guide lines for competent authorities to regulate the installation of new electromagnetic sources allowing better management of the environment.

INTRODUCTION

The use of radio frequency systems for transmitting radio and television signals is widespread in Italy. In Brescia these systems are located in two sites on the Maddalena mountain, just to the east of the town [1]. Recently the use of mobile telephone systems has risen sharply and market devolution has led to the arrival of many new telecommunications networks, the result being a large increase in the number of base transceiver stations (BTS). This has generated a high concentration of BTS in the town. Therefore, in our opinion, it is useful to launch a campaign of high frequency (HF) electric field (E_{HF}) measurement in Brescia to evaluate the impact of the different sources. A map of the distribution of HF sources in Brescia is shown in Figure 1.

For the sake of completeness, the extremely low frequency (ELF) electric (E_{ELF}) and magnetic (H_{ELF}) fields were also measured due to the presence of power lines and power stations in the town.

MEASURING METHODS

The map of Brescia was divided into 1 km by 1 km squares. The densely populated area of the town was divided into 0.5 km by 0.5 km squares. The E_{HF}–field, E_{ELF}–field and H_{ELF}–field were measured at 38 of the intersection points on the grid. The E_{HF}–field was measured using a PMM 8053 broadband instrument equipped with an EP330 isotropic electric probe (frequency range 100 kHz – 3 GHz; sensitivity 0.3 V/m). The E_{ELF}–field and H_{ELF}–field were measured using Wandel & Goltermann EFA 3 isotropic probes. At one of the 38 points, spectral analysis was performed with an Advantest U3641 analyser equipped with Rohde & Schwartz antennae for the range of radio and television broadcasting frequencies and for the frequencies of mobile telephone systems (900 MHz and 1800 MHz). All the probes were positioned 1.5 m above the ground, representing the median position of the human body. Care was taken to prevent interference caused by the proximity of pedestrians during measurement [2]. Measurements were made according to Italian law [3], by positioning the probes on a dielectric tripod and measuring root-mean-square (rms) electric and magnetic values over 6-minute periods. The measuring time was 30 minutes for each position. The time interval was chosen from 10 a.m. to 1 p.m. to take into account the variability in daytime telephonic traffic.

RESULTS AND DATA ANALYSIS

In the field of HF measurement, the problem of accuracy and precision is of primary concern. The field variations found in mapping a large area should refer to a true variation in the electromagnetic field or to the method of measurement.

Instrument sensitivity and precision were evaluated first of all. Such an estimate becomes highly significant since the measurement range is quite close to the sensitivity of the instrument. All values below 0.3 V/m were assumed to be 0.3 V/m, which is the declared sensitivity. A correction factor (CF) was also introduced in order to correct the measured value for the instrument response function to the electromagnetic field strength (Figure 2). Linear interpolation was applied to the response function in order to fit the measured values.

Based on information obtained from the manufacturer, the instrument uncertainty was estimated to be ±1 dB. The instrument response function to the field frequency introduced a ± 0.5 dB uncertainty and isotropicity of ±1 dB. Furthermore, ±0.75 dB were added to correct for the environmental temperature (+5°C on average). The total resulting uncertainty is ±1.68 dB.

The corrected E_{HF}–field values and the estimated absolute errors are shown in Table 1. These values were used for mapping purposes. It should be noted that some values are below 0.3 V/m and their standard deviation is greater than the standard deviation of non-corrected data, as expected from the shape of the instrument response function.

The E_{ELF}–field and H_{ELF}–field measurements are also given in Table 1. In a number of positions the E_{ELF} is below the instrument sensitivity (1 V/m) or negligible for mapping purposes, except for position 27 where power lines generated a 254 V/m electric field. Considering an HF instrument response of at least -25 dB at 50 Hz, the contribution of the low frequency electric field is not negligible.

The H_{ELF} value measured generally has the same order of magnitude as instrument sensitivity (0.05 μT).

As regards the analysis of spatial distribution of E_{HF}–field, the average value is 0.5 ± 0.3 V/m, corresponding to the 50th percentile of the data distribution. The first standard deviation is assumed to represent the local field variability. These can be considered reasonable assumptions but they still need to be verified experimentally. Figure 3 shows the measured E_{HF}–field values; the band between dotted lines represents the first standard deviation and the full bars are the instrumentation uncertainty. In five positions the electric field is higher than average, beyond the estimated uncertainty limit.

In order to evaluate the correlation between the spatial distribution of the HF sources and the variations observed in the values measured, an algorithm was developed to calculate, for every field value, a correction factor F_{tv} – depending on the distance from radio and television sources – and a correction factor F_{BTS} – depending on the number of base transceiver stations in a 500-m radius of the measurement point.

The algorithm main structure assumes that:

if

d = distance between measurement point and radio/TV sources

D_{max} = diameter of the considered area

then:

$FP_{tv} = 1- d/D_{max}$

If

n = number of BTS in a 500-m radius of the measurement point

N_{max} = maximum number of BTS in a 500-m radius of the measurement point

then:

$FP_{BTS} = n/ N_{max}$

In conclusion: $F_{tv} = FP_{tv} /(FP_{tv} + FP_{BTS})$

At each measurement point, the radio/TV and BTS contribution to the total electric field is represented by the product of F_{tv} or F_{BTS} and the electric field measured.

The field values measured and the values calculated for radio/TV and BTS were normalized to their respective maxima. The normalized values due to each source were compared with the normalized total value by calculating the gross error. The correlation between the total field and the radio/TV contribution was found to be the 87% (gross error 13%) and the one referred to BTS was found to be 59% (gross error 41%).

The algorithm was extended to the whole town in order to evaluate the distribution of the radio/TV contribution. In Figure 4 the background represents the radio/TV contribution to the electric field, and the dots represent the E_{HF}–field measured.

Spectral analyses will be performed in order to complete the town mapping. So far a preliminary narrowband measurement has been performed in position 38, to the NE of the town centre. The range of radio and television broadcasting and of mobile telephone system frequencies was scanned in 10 MHz steps, in three orthogonal directions. Only peaks above 55 dBμV/m were considered. The contribution of each HF source is shown in Table 2. The broadband value measured in the same position is also given.

CONCLUSIONS

Initial results show close agreement between the narrowband measurements and the electromagnetic field calculated, although the spectral analysis needs to be completed.

The spatial electric field distribution is related to the radio/TV contribution rather than to the presence of BTS. It must be stressed that the results are based on measurements at ground level. A different condition may be found at a higher level, where the BTS contribution is more significant.

The mapping suggests it is advisable to move radio/TV systems further out of town in order to reduce human exposure to electromagnetic fields.

The authors hope this work will encourage the authorities to develop policies for controlling electromagnetic pollution.

REFERENCES

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Figure 1: Distribution of HF sources in Brescia (the pale symbols represent the BTS and the larger dark squares represent the locations of radio and television systems).

Figure 2: Linearity Correction Factor (CF) for the PMM EP330 probe.

Figure 3: E_{HF}–field measured, instrumentation uncertainty (solid bars) and first standard deviation gap (band between dotted lines).

Figure 4: Contribution of radio and televion to the electric field (background) and E_{HF}–field values measured (dots).

Table 1: The E_{HF}–field, E_{ELF}–field and H_{ELF}–field values measured at 38 points in the town of Brescia.

Table 2: Contribution of each HF source to the electric field.