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Measurement of the environmental broadband electromagnetic waves in a mid-size European city

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ABSTRACT

In this paper, the level of exposure to broadband radiofrequency electromagnetic field in a mid-size European city was evaluated in accordance with the International Commission on Non-ionizing Radiation Protection guidelines from 1998. With the aim to analyse all the potential electromagnetic waves present in the city up to 18 GHz, a total of 271 locations distributed along Terrassa (Spain) have been measured. To show the results in an easy-to-interpret way by the citizen, the results have been represented in a set of raster maps. The measurement results obtained showed that the electromagnetic wave measured in all broadband frequency range along the city is much lower than the safety level according to the international regulations for both public and occupational sectors.

1. Introduction

Nowadays, due to the progress of wireless technologies, the industrialized countries population is exposed to a complex mix of electric and magnetic fields on a broadband frequency range due to man-made sources. Public concern over the potential health effects from radiofrequency electromagnetic fields (RF-EMF) due to the current environmental electromagnetic radiation is a major issue in our society. RF-EMF main sources e.g. radar, radio and TV broadcast facilities, mobile phones and their base stations, induction heaters and anti-theft devices. At RF the fields penetrate a short distance into the human body and the tissues absorb their energy, rising the cell's temperature. Therefore, research efforts are being carried out in order to determine potential adverse health effects in the long-term even for low-level RF exposure (World Health Organization, 2002). Anyway, it is mandatory to reduce the electric and magnetic field magnitude as much as possible to minimize potential health hazard and, simultaneously, to preserve the current and future services and wireless applications (Spanish Government, 2001). With regard to the RF-EMF exposure regulation, most of the European countries, fix the exposure limits of their national standards on the guidelines set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) from 0 to 300 GHz (ICNIRP, 1998). Others have preferred to impose more restrictive limits by following a precautionary approach in terms of electric or magnetic field magnitude (Mazar, 2016). In any case, in order to protect the population against harmful effects from electromagnetic exposure, the regulation frame determines to minimize the electromagnetic exposure level of the general public and to comply with the limit restrictions.

Several research works have been developed in order to characterize the impact of RF-EMF for the general public in real scenarios, considering the RF communication specific frequency bands. Those works include communication standards such as FM radio, TV-broadcast, GSM, DCS, DECT, UMTS and Wi-Fi, typically up to 3 GHz (Bolte and Eikelboom, 2012; Urbinello et al., 2014; Aerts et al., 2013). Some others are extended up to 6 GHz, including WiMAX and ISM (Bhatt et al., 2016). Moreover, some researchers have been focused on specific population segments such as children or adolescents (Guxens et al., 2016; Calvente et al., 2015; Ibrani et al., 2014; Roser et al., 2016) and occupational sectors (IEEE Standard for Military Workplaces, 2014; Fuentes et al., 2008; Barbilori et al., 2011). Those works, usually consider on-body calibrated exposimeters and they take into account the different uplink and downlink narrow frequency bands and determine the total electric field exposure by means of the sum of all the peak field values obtained. In fact, according to the World Health Organization, due to the ubiquitous source of RF radiation the percentage of all people being exposed to RF electromagnetic radiation is rapidly approaching the percentage exposed to polluted air (Lin, 2016) and therefore, more research must be devoted to this crucial issue. In addition, it is necessary to extend the RF-EMF exposure assessment to broadband frequency measurements including fields beyond 6 GHz. This fact will be mandatory in the future because of the deployment of new wireless standards such as the fifth-generation mobile communication systems (5G) (Colombi et al., 2015; Zhao et al., 2015). Moreover, it is fundamental to locate the main transmitting antennas

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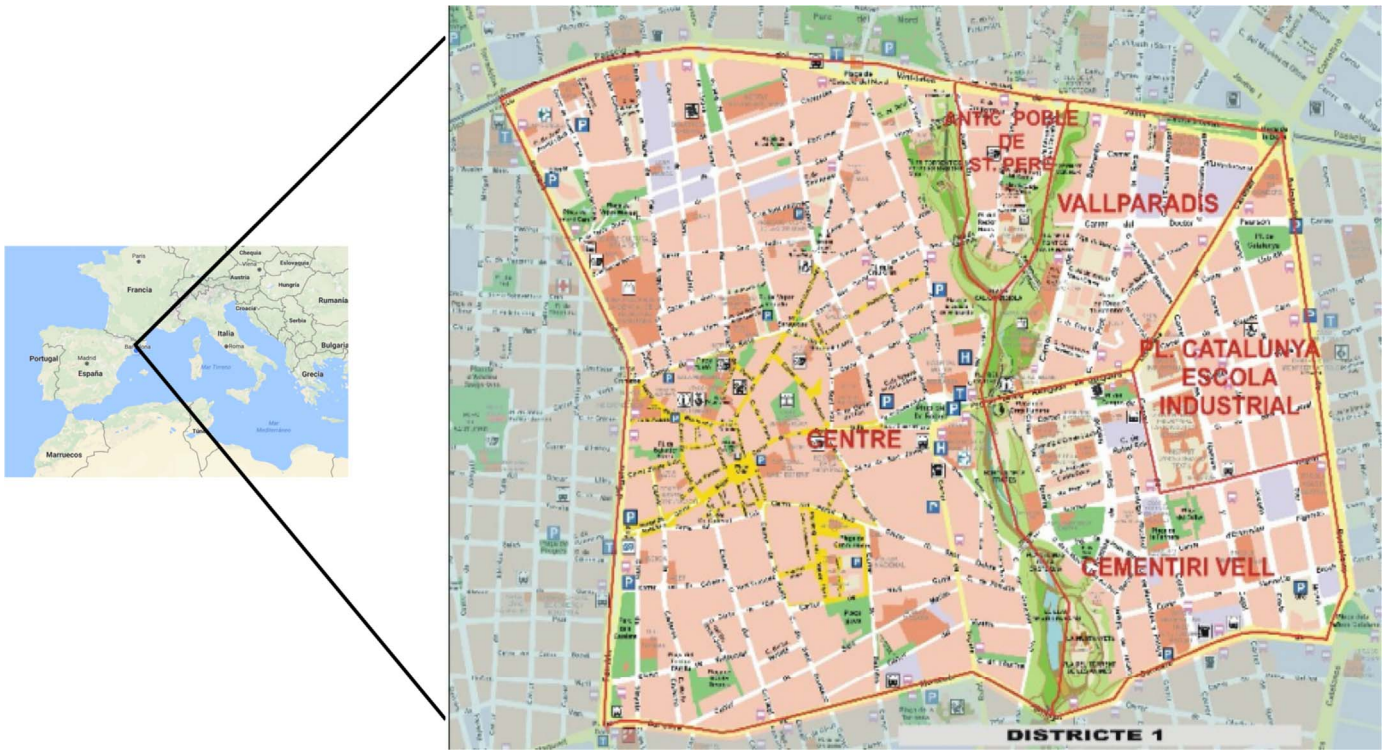

Fig. 1. Area under evaluation. District 1 of Terrassa comprises five neighborhood in an area of 2.25 km^2 and 35.277 inhabitants.

Fig. 2. Example of measurement procedure.

Fig. 3. Measurement points distribution along the city.

distributed across the electromagnetic areas under study and assess their field regions and boundaries (Vallauri et al., 2015).

To the best knowledge of the authors, this paper expands, for the first time, the characterization of the level of exposure to time-varying electric fields from 6 GHz up to 18 GHz for the general public in a mid-size city real environment. The measurement scenario corresponds to Terrassa (Spain), a more than 200.000 population city located in the Barcelona metropolitan area. The electric field measurements have been carried out by means of an electromagnetic field meter and a broadband isotropic probe (300 kHz–18 GHz) to assess the radioelectric environment and all the main potential RF sources, according to the ICNIRP guidelines. In addition, those measurements are independent on the individual, avoiding the need of using an exposimeter and the uncertainty of the body impact on the test. The districts of the city have been homogeneously meshed with a specific refinement measurement for the transmitting base station antenna areas. The proposed measurement technique was successfully used by the authors in an indoor measurement scenario for general public RF-EMF exposure at the UPC Terrassa Campus (Gil and Fernández-García, 2016). The aim of the work is to obtain a realistic broadband frequency electromagnetic radiation map of the city up to 18 GHz and to check compliance with international personal RF-EMF exposure guidelines.

The remainder of the paper is organised as follows. Section 2 describes the material and methods including the definition of the population area, test instrumentation and measurement procedure in accordance with the ICNIRP guidelines. In Section 3 the electric field experimental results in the city districts are shown and discussed. Finally, in Section 4 the main conclusions are drawn.