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Exogenous radiofrequency electromagnetic exposure of outdoor workers who are managing touristic boat journeys

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Abstract

The frequency pattern of radiofrequency electromagnetic field exposure of outdoor workers, who are managing touristic boat journeys, has been investigated using frequency-selective portable, autonomous, data-loggers which allow recognizing the time pattern of exposure level and the composition of its sources. Significantly different patterns of relative contributions to recorded workers' exposure from various sources were found during activities at pier (dominating base stations downlink components of exposure) and during the touristic journey by boats (dominating mobile terminals uplink components, with exposure contribution also from radio and television terrestrial emitters). The differences found in the workers' exposure pattern recorded in particular microenvironments need attention when considering the protection measures aimed at improving the electromagnetic environment there.

1. Introduction

The workers of various jobs stay many hours per shift in microenvironments accessible by public, which is affected by exogenous (not manageable by workers) radiofrequency electromagnetic radiation (RFR) emitted by radio-television terrestrial broadcasting antennas and public mobile communication systems, i.e. fixed base transceiver station (BTS) antennas emitting downlink (DL) signals to mobile terminals (MT), such as smartphones and tablets used for voice and data wireless exchange through GSM/LTE/5G communication protocols. In some cases RFR exposure of workers may also be caused by the nearby use of personal MTs, emitting uplink (UL) signals for wireless internet access, voice communication or picture/video uploading, for example in public transportation facilities or touristic facilities. The outdoor activities of workers managing tourist river boat (TRB) journeys take place in two main microenvironments: at the pier before and after the journey, and on the boat (outdoor on an open upper deck) during the journey. The outdoor environment of TRBs and piers is always affected by RFR emitted by public mobile communication systems (BTS-DL emissions), and in many cases also by RFR emitted by the RTV emitters located along the coast. During the journey it is also affected by RFR emitted by passengers' personal MTs emitting UL signals.

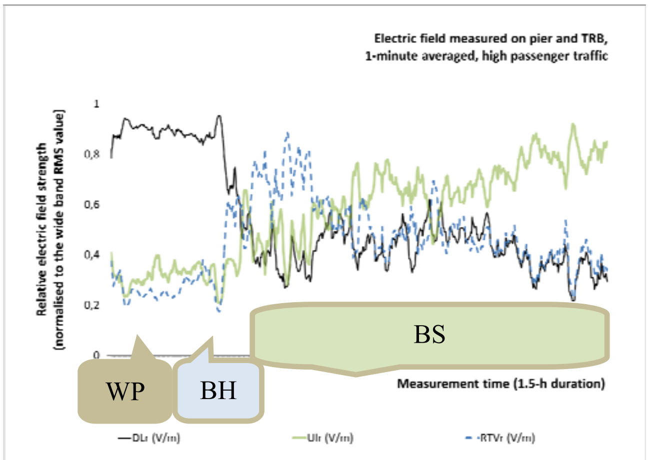
2. Method

Frequency-selective portable, autonomous, RFR data-loggers were used following an already-developed protocol [1-3] to investigate the frequency pattern of exposure of outdoor workers who are managing journeys by TRBs (i.e. recording the time pattern of exposure level changes and the composition of its sources recognized by frequency of emitted RFR). Case studies were performed with high passenger traffic during typical journeys by TRBs of various size operating touristic journeys inside and nearby harbors belonging to the top touristic destinations (Gdansk-Poland, Kazimierz Dolny-Poland, and Tokyo-Japan).

Root-mean-square (RMS) electric field strength (E, in V/m) values were recorded there with a four-second sampling rate, simultaneously for frequency narrow-band channels covering typical components of RFR emitted from the communication system. Wide-band RMS values (TOTAL values) covering all exposure components (i.e. the square root of the sum of all squared components) were also evaluated.

3. Results

Significantly different frequency patterns of relative contributions to the TOTAL workers' exposure from various types of RFR emissions, from nearby BTSs and MTs used by passengers, were found between exposure recorded during activities at piers and during the touristic journey by TRBs (Fig. 1). In the measurement results collected during walks along the piers, UL-emissions were not recorded (i.e. not exceeded the sensitivity of the used data-logger). The main exposure contributions there were from DL-emissions from BTS antennas. Contrary, during the journey at the open deck of TRBs, the significant contribution of UL-emissions from MTs was found in collected measurement results – which is increasing with the distance from the coast, while also there RFR from DL-frequency bands dropped down below the data-logger sensitivity - similar to various passenger vehicles, such as trains or buses.



Notes: (a) measurements description: WP – during walking along the pear (near the densely populated area), BH – on boat in the harbor, BS – during the sea-going sailing ; b) exposure components: DL – RMS values covering all downlink signals emitted by BTSs, UL – RMS values covering all uplink signals emitted by MTs used by passengers RTV – RMS values covering all radio-television signals; all values (r) normalized to the wide-band RMS value of exposure to RFR.

Figure 1. The example of relative frequency contributions to the wide-band RMS value from various types of emissions recorded on pier and on outdoor upper deck of TRB doing local sea-going journey, measured during the high passenger traffic season.

Regardless of the size of the TRBs and the geographical location of the research, visual observations during touristic journeys noted significant up-streaming activities by many tourists using MTs (UL-emissions), which are a significant source of workers exposure during services with high passenger traffic. Mentioned UL-exposure components are not present during the low season and also not common in other microenvironments (such as the pier). In some locations, the open upper deck of TRBs may approach BTS antennas closer than the regular space accessible by pedestrians, which may also contribute to the actual RFR exposure during journeys (DL-exposure components), as well as emissions from radiophones and RTV broadcasting, penetrating the open surroundings of TRBs during short river, harbor or sea-going journeys.

The pick values of EMR recorded in particular frequency bands (i.e. emitted from different sources) in all the studied microenvironments reached comparable levels. TOTAL values measured during journeys were up to several times lower than in the harbours. The mean values of RFR recorded in particular frequency bands on the piers (DL-components) and on the TRBs (UL-components) were at a comparable level, but from different sources in particular locations. The absolute level of recorded RFR reached 3 V/m, which is significantly lower than the reference levels used to evaluate the health hazards caused by the thermal effects of RFR exposure, but it is comparable to the basic level of immunity to electromagnetic interference caused by such exposure which is required from electronic devices [3-5].

4. Conclusions

The frequency pattern in the dominating components of exposure found in the RFR measured in the particular studied microenvironments need attention when considering the protection measures applied to reduce any unnecessary electromagnetic exposure to workers and passengers on TRBs, or to reduce potential electromagnetic interference in electronic devices used there (including medical implants and body-worn devices).

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