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► **To cite this version:**

Yarui Zhang, Shanshan Wang, Jiang Liu, Ce Zheng, Theodoros Samaras, et al.. Assessment of RF-EMF Exposure in Shopping Centers and Covered Markets in Paris. BioEM 2024: The International Conference in the field of BioElectromagnetics, Jun 2024, Platania-Chania, Greece. hal-04739377

HAL Id: hal-04739377

<https://hal.science/hal-04739377v1>

Submitted on 16 Oct 2024

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Assessment of RF-EMF Exposure in Shopping Centers and Covered Markets in Paris

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INTRODUCTION

The widespread use of wireless communication technologies has led to a significant public perception of risk associated with exposure to radiofrequency electromagnetic fields (RF-EMF), and the deployment of the 5G wireless network has further increased this risk [1, 2]. Consequently, considerable efforts have been dedicated to assessing EMF exposure [3]. This study aims to assess the levels of RF-EMF to which the public is exposed in densely populated urban areas. Specifically, it focuses on Paris City's shopping centers and covered markets, which attract a significant daily flow. The evaluation covered six major shopping centers and the most frequented covered markets in Paris. Measurements were conducted using a frequency-selective personal dosimeters named EME Spy Evolution, spanning a range of frequency bands: 700MHz, 800MHz, 900MHz, 1800MHz, 2100MHz, 2600MHz, 3500TDD, and two Wi-Fi bands. A comprehensive analysis across different technologies, including 2G, 3G, 4G, and 5G, has been conducted, focusing on downlink (DL) exposure. The present contribution examines the data collected from these various scenarios and over different frequency bands to provide a detailed understanding of RF-EMF exposure in these high-traffic urban settings.

METHODS

In this section, the measurement device is first described. Then, the measurement protocols and scenario choices are detailed, followed by a brief introduction to data pre-processing.

Measurement device

The EME Spy Evolution is a frequency-selective portable EMF meter. It is equipped with a tri-axial electric field (E-field) probe, capable of covering a frequency range from 80MHz to 6GHz. This advanced tool allows for the capture of up to 20 user-defined frequency bands. In our study, we have selected 15 specific bands, necessitating a minimum sampling interval of 6 seconds. Our primary focus lies on 6 DL bands, 1 TDD band, and 2 Wi-Fi bands, as previously mentioned. Each frequency band has its sensitivity, indicating the lower detection limit, varying from 0.02 to 0.045 V/m, and an upper detection limit of 6V/m.



Figure 1: The EME Spy Evolution (left), and the experimenter (Right)

Scenarios and measurement protocol

The measurement scenarios include 6 main shopping centers (*Galerie Lafayette, Italie 2, etc.*) and 10 covered markets (*Enfant Rouge, Saint-Germain, etc.*). A total number of 5224 measurement points on 9 frequency bands are obtained, i.e. more than 500 minutes of measurements. The dosimeter is placed in a small bag in front of the experimenter, as shown in Fig. 1. The experimenter, carrying the Spy, walks through each scenario and generally stays at least 15 minutes inside each. For small markets, the dwell time is shorter.

Data pre-processing

The measurement data is pre-processed in two steps. First, the measurements are denoised based on the sensitivity of each frequency band. Then, since the presence of the human body of the experimenter can potentially have an impact on the precision of the measurements, calibration measurements were carried out using the dosimeters and a reference system (Tektronix RSA 306B). The correction coefficients are applied to assess the average E-field level taking into account the influence of the body. They are obtained from the ratio of the average values measured by the reference system and the dosimeters. The application of these coefficients can reduce the influence brought by the human body on the average level of the E-field value.

RESULTS

In this section, the results of our measurements are presented. Initially, a comparative analysis of measurements obtained from shopping centers and covered markets is given in Fig. 2, focusing on the total E-field equivalent in the 900 band. We can observe that shopping centers exhibit higher exposure levels. Although covered markets are nearly outdoors, which means less shielding effects from the building structure, it still presents a lower average exposure level than shopping centers. This difference may be attributed to the frequent installation of indoor antenna systems within crowded shopping centers, which are designed to facilitate connectivity for visitors.

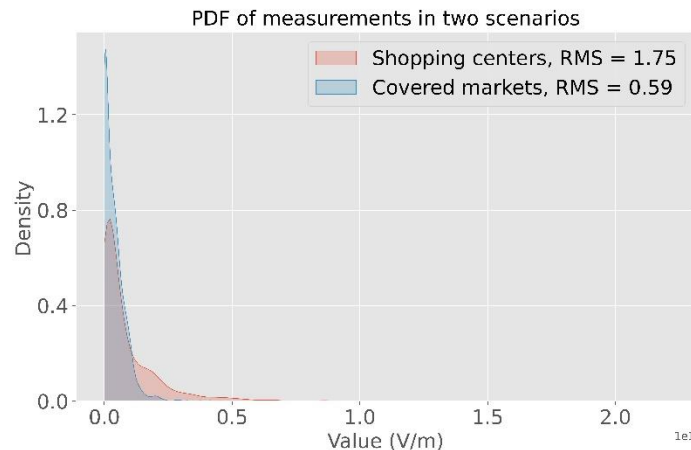


Figure 2: Probability Density Function (PDF) of measurements in two main scenarios.

Fig. 3 provides more details on the contribution of each frequency band to the exposure levels in various shopping centers. Generally, the 700DL, 800DL, and 900DL bands contribute significantly to the exposure levels, indicating that 2G, 3G, and 4G networks are associated with higher exposures compared to 5G and Wi-Fi bands.

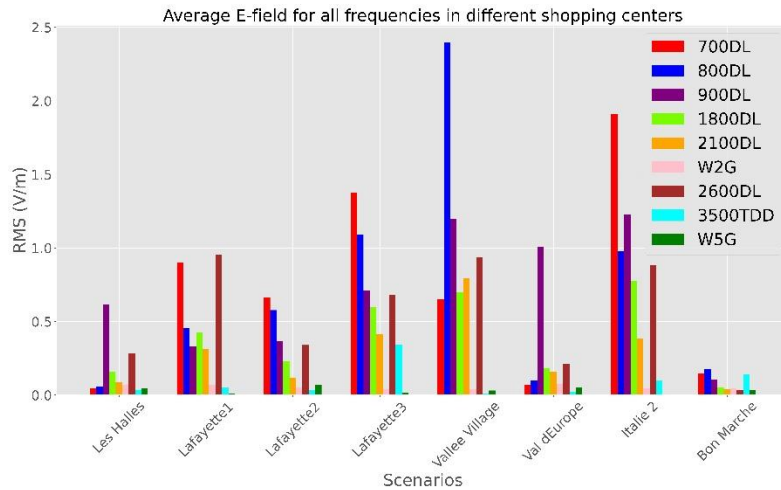


Figure 3: Comparison of RMS of E-field in different shopping centers over frequencies

DISCUSSIONS

In indoor environments, the sources of exposure are diverse. The exposure can originate not only from nearby base stations but also from various indoor sources. This diversity renders the analysis and characterization of exposure levels at a specific point more complex than measurements obtained in outdoor settings. Further analysis could be conducted to characterize the overall distribution of the data. Additionally, exploring the impact of indoor antennas on exposure levels can be another potential direction to investigate.

CONCLUSIONS

In conclusion, this study provides a comprehensive assessment of RF-EMF exposure levels in Paris's shopping centers and covered markets. The results show that 2G, 3G, and 4G networks contribute to higher exposure levels compared to 5G and Wi-Fi bands. Moreover, shopping centers, often equipped with indoor antenna systems, exhibit higher RF-EMF exposure levels than the almost outdoor environments of covered markets.

ACKNOWLEDGEMENTS

This research was conducted as part of the SEAWave EU project, which is supported by funding from the Horizon Europe Research and Innovation program under Grant Agreement No. 101057622. Additionally, the work is part of the French project Beyond 5G, funded by Bpifrance and MINEFI.

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