



Study of RF Electromagnetic Exposure in the subway trains

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Abstract

Exposure to radiofrequency (RF) electromagnetic fields (EMFs) in public environments is continuously evolving due to advancements in various communication systems. In 2025, we measured RF-EMF exposure in the subway environment using a personal measurement device, following the same methodology as in 2023. A comparative analysis revealed that total exposure levels in 2025 were generally higher than in 2023.

1. Introduction

Monitoring and compliance with international standard limits [1],[2] of RF-EMF exposure have become increasingly import due to the rapid expansion of electronic devices and wireless communication technologies.

As an environmentally friendly and sustainable mode of transportation, subway systems are widely used in medium- and large-sized cities worldwide. Proximity to metallic structures near RF-EMF sources can elevate exposure levels in confined microenvironments, such as public transportation and subway trains.

This study aims to assess personal exposure to RF-EMF in the subway environment and compare it with recorded values from 2023.

2. Material and method

The study on personal exposure to RF-EMFs was conducted using the ExpoM-RF4 (Fields at Work GmbH, Zürich, Switzerland), with measurements taken every 5 seconds. The personal exposure meter (PEM) measures 25 frequency bands ranging from 80.5 MHz to 5850 MHz, for wireless communication systems. The measured frequency bands are as follows: FM (80.5-115.5 MHz), TV1 (177.5-212.5 MHz), TV2 (470-570MHz), TV3 (570-670.5), TV4(671-771 MHz), 4G800UL (817.5-852.5 MHz), 4G800DL (862.5~897.5 MHz), 4G900UL(900.5-935.5 MHz), 4G900DL (942.5-977.5 MHz), 4G1800UL (1702.5-1777.5 MHz), 4G1800DL (1797.5-1872.5 MHz), 3G&4G2000UL (1912.5-1987.5 MHz), 3G&4G2000DL (2102.5-2177.5 MHz), 4G2600UL (2500-2535 MHz), 4G2600DL (2620-2655 MHz), 5G1 (3400-3500 MHz), 5G2 (3500-3600 MHz), 5G3 (3600-3700 MHz), Wi-

Fi 2.4G (2400-2500 MHz), Wi-Fi 5G1 (5150-5250 MHz), Wi-Fi 5G2 (5350-5450 MHz), Wi-Fi 5G3 (5450-5550 MHz), Wi-Fi 5G4 (5550-5650 MHz), Wi-Fi 5G5 (5650-5750 MHz), Wi-Fi 5G6 (5750-8250 MHz). The upper detection limit of the PEM is 20 V/m, while its sensitivity varies across different bands, with a minimum sensitivity of 0.009 V/m.

The RF-EMF measurement was conducted in the subway system of the public transportation network in Daejeon, Korea, a medium-to-large-sized city, during the morning rush hour (8:00-9:00). The measurement was performed with the subject seated on a subway seat and holding the backpack containing PEM on their lap. The backpack and the body were kept at a distance of at least 20 to 30 cm.

3. Results and discussion

Figure 1 shows a box plot of the measured frequency bands and total RF-EMF exposure in 2025. The mean value was 1.45 V/m for total RF-EMF, with 0.01 V/m for broadcasting (FM, TV1-TV4), 0.032 V/m for uplink (4G800UL, 4G900UL, 4G1800UL, 3G&4G2000UL, and 4G2600UL) 0.275 V/m for downlink (4G800DL, 4G900DL, 4G1800DL, 3G&4G2000DL, and 4G2600DL), 0.361 V/m for 5G(5G1-5G3), 0.279 V/m for Wi-Fi 2.4G, and 0.047 V/m for Wi-Fi5G (Wi-Fi5G1-Wi-Fi5G6). The highest exposure level was measured in the 5G band, while the exposure level was very low in the broadcasting band. In the subway, public Wi-Fi services are available on both 2.4 GHz and 5 GHz band has a utilization rate 2.5 times high than that of the 5 GHz band, and its exposure level is six times greater.

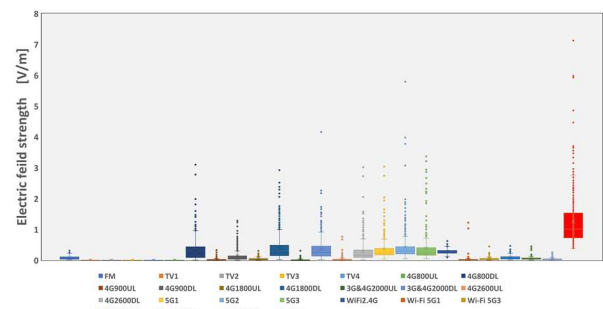
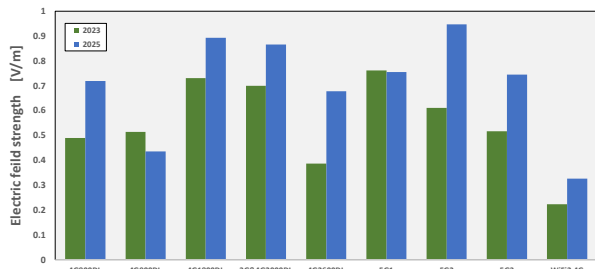


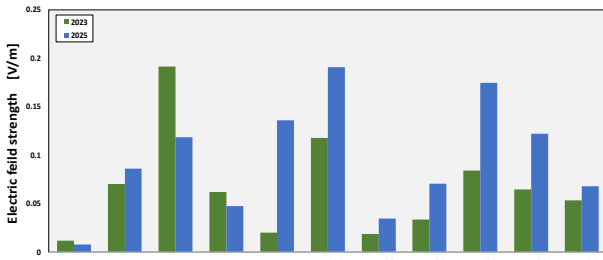
Figure 1 The statistical distribution of the electric field strength

The measurement results from 2025 were compared with those from 2023. To analyze past and present data, the maximum value of the 6-minute averaged electric field strength was assessed for (a) Wi-Fi 2.4G, downlink, and the 5G band, and (b) Wi-Fi 5G and uplink, as shown in Figure 2. Since the exposure level in the broadcasting band was very low, it is not included in Figure 2.

As shown in Figure 2, the exposure levels in 2025 increased by a factor of 1.2 to 2.1 compared to 2023 in most frequency bands. The exposure level from mobile communication (3G–4G downlink and 5G) is higher than that of the Wi-Fi 2.4 GHz band, while the exposure level is lower in the uplink and Wi-Fi 5 GHz band in both 2023 and 2025.



(a) downlink, 5G, and Wi-Fi 2.4G



(b) uplink and Wi-Fi 5GHz band

Figure 2. The maximum value of the 6-minute averaged electric field strength in 2023 and 2025

Figures 3 and 4 present the CDF of the total RF-EMF level and the box-and-whisker plot for all measured frequency bands in 2023 and 2025, respectively.

As shown in Figure 3, 70% of the total RF-EMF level in 2023 was measured with an electric field strength of less than 1 V/m, while 60% of that in 2025 was measured with an electric field strength of less than 1 V/m.

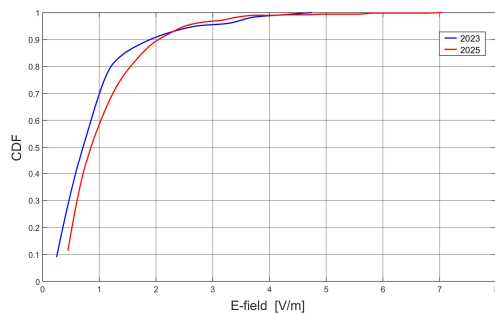


Figure 3. CDF of total RF-EMF level for all measured frequency bands in 2023 and 2025

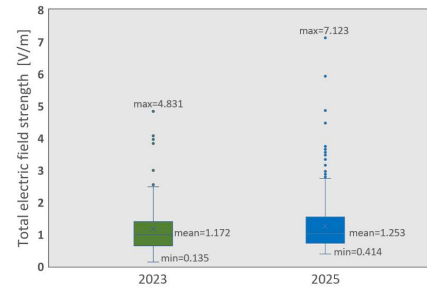


Figure 4. Box and whiskers of total RF-EMF level for all measured frequency bands in 2023 and 2025

The overall average exposure values for 2023 and 2025 are similar. In 2023, electric field strengths ranged from 0.639 V/m to 1.349 V/m, while in 2025, they ranged from 0.719 V/m to 1.539 V/m. Higher electric field strengths were recorded in 2025, with a maximum of 7.1 V/m compared to 4.83 V/m in 2023. Based on currently measured and analyzed data, the total exposure level in 2025 is expected to be higher than that in 2023. However, additional data collection and further analysis are required for more precise comparisons.

Acknowledgements

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References

- [1] “Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)”, *Health Physics*, vol. 18, May 2020 pp. 483-524, doi:10.1097 /HP.0000000000001210.
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