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The Wireless EMF Monitoring in Sensitive Areas around Kindergartens and Schools

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***Abstract* – The appearance of modern electromagnetic field (EMF) monitoring networks, such as the Serbian EMF RATEL network, has enabled wireless observation of EMF level in various surroundings, particularly in areas where people experience increased sensitivity to EMF exposure. Such areas are residential locations, where persons can reside many hours per day, kindergartens, schools, hospitals and children's playgrounds. They demand daily, comprehensive EMF monitoring, compliance checking with prescribed reference levels, as well as transparent dissemination of acquired results. This paper presents an analysis of EMF monitoring in sensitive areas on a case study of two kindergartens and an elementary school in the Serbian city of Novi Sad.**

I. INTRODUCTION

Mobile radio networks are present worldwide, providing various services and benefits to increase the quality of modern person's life [1]. However, their base stations are well known sources of electromagnetic fields (EMF), causing a strong debate due to their alleged adverse effects on health [2].

Consequently, researchers have dedicated a great effort to measure and monitor human exposure to EMF, in order to disclose physical mechanisms of interaction between EMF and human tissues, as well as any undesirable exposure endings on health [2], along with beneficial ones [3].

In line with those activities, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [4] has published the "Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)" – ICNIRP 2020 [5], summarizing available scientifically-based guidelines for health protection against EMF exposure.

Although the ICNIRP 2020 Guidelines are not mandatory, they have been considered by many international and national bodies as a reference for EMF legislation, which will act as safeguard for population against EMF exposure.

Regarding the significance of the EMF exposure threats, innovative monitoring methods and strong experimental evidence are persistently expected and required [6]. Thus, as a contribution to this subject, the Serbian EMF RATEL network [7] offers the approach of continuous and wireless broadband EMF monitoring [8].

The paper is organized as follows. Section II will briefly report essentials on the EMF RATEL network and its monitoring approach, while Section III will present a case study of monitoring in areas close to two kindergartens and an elementary school. Section IV will show the results of the analysis of acquired EMF data, while Section V concludes this paper.

II. THE EMF RATEL MONITORING NETWORK

The Serbian EMF RATEL monitoring system is based on autonomous EMF monitoring sensors, located over the area of relevance, as illustrated in Fig. 1.

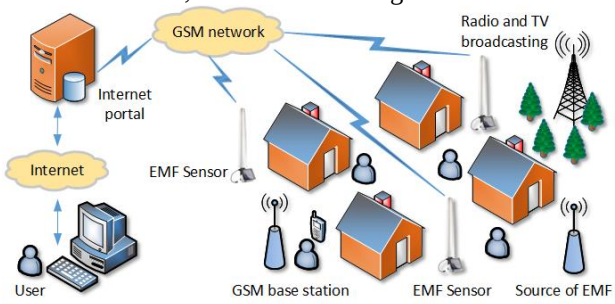

Fig. 1. The EMF RATEL concept.

Sensors run long-term monitoring of EMF level, on predetermined and permanent sites, storing acquired measurement results in their internal memory, periodically transferring data to EMF RATEL database [8], over the GSM network.

After processing, measurements data are disseminated through an open Internet portal [7], with the aim to timely inform community on EMF levels in their surroundings.

The EMF RATEL network has been designed to use EMF monitoring sensors displayed in Fig. 2 [9]-[11].

Fig. 2. Sensors in EMF RATEL system.

Sensors monitor the contribution of neighboring EMF sources, in a wide range of frequencies (i.e., they perform wideband monitoring), regardless of the EMF source position relative to sensor (isotropic measurement). Sensors are compliant with the ITU-T K.83 standard [12] and ready for 5G [9]-[11], [13].

Regarding a case study of monitoring in sensitive areas of two kindergartens and an elementary school, in the Serbian city of Novi Sad, the wideband EMF monitoring was performed using: AMB 8059 sensor with EP-1B-03 electric field probe [9], covering the frequency range from 100 kHz to 7 GHz, and MonitEM sensor with WPF8 electric field probe [10], covering the range 100 kHz to 8 GHz.

Both probes provide cumulative level of the electric field strength, i.e., the overall field strength on location, which originates from all neighboring EMF sources.

III. A CASE STUDY OF EMF MONITORING

The EMF RATEL system is designed for the observation of EMF in urban areas, employing sensors in major cities of the Republic of Serbia, whose number is associated with the number of the city population. Sensors mostly cover areas of special interest in the cities, providing daily EMF monitoring to the local community.

Regarding the city of Novi Sad, six sensors are currently installed in the areas of special interest, marked with blue circles in Fig. 3. However, for this case study, only three of them were considered, marked with additional red circle line. The intention is to present continuous monitoring and comprehensive analysis of measurement data, which could be valuable for residential community and their concerns on EMF exposure, mainly when considering precaution on the sensitive part of the population.

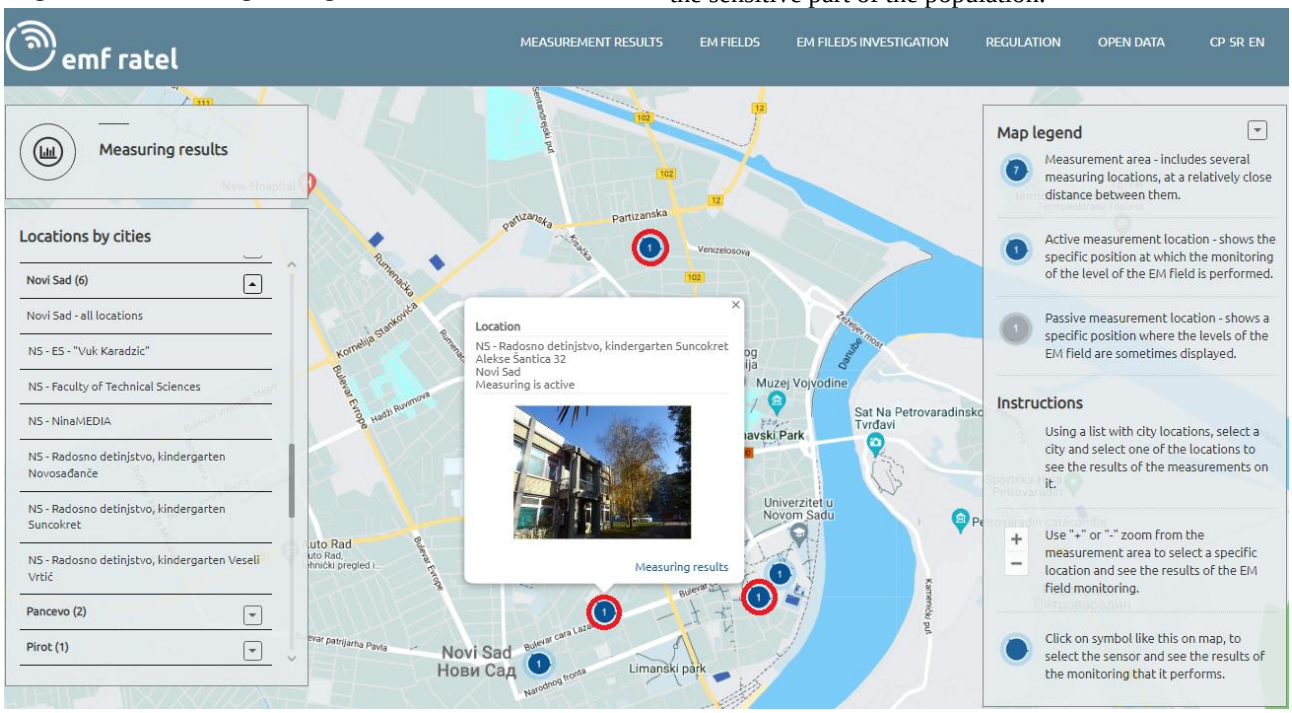

Fig. 3. The EMF RATEL sensors in the city of Novi Sad (three of them used for a case study) [7].

The chosen locations are the kindergartens "Suncokret" and "Veseli vrtic", both located in the southern part of the city and the elementary school "Vuk Karadzic", which is in the northern part of the city, as shown in Fig. 3.

Those locations have been carefully chosen as typical representatives of sensitive places in Novi Sad city, with high, medium and low density of residential population.

A. Basic overview of monitoring locations

The kindergarten "Suncokret", highlighted with red rectangle in Fig. 4, is situated in a highly populated part of the city. It is surrounded by the elementary school "Sonja Marinkovic" on north-west, several twelve-floor residential buildings on south-east, and a few individual households on the south-west.

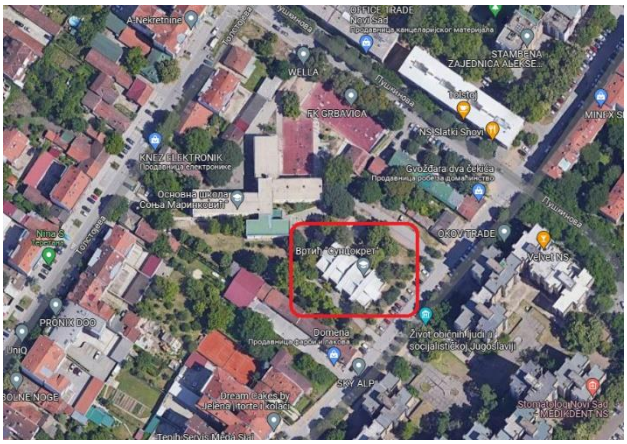

Fig. 4. Location of the kindergarten "Suncokret".

Kindergarten “Veseli vrtic”, marked with red rectangle line in Fig. 5, is situated in a medium-populated residential area, within the campus of the University of Novi Sad. The location is encircled by facilities of student’s dormitory “Slobodan Bajic” and the building of Science-Technological Park, on the north-west, elementary school “Jovan Popovic” on the south, as well as several eight-floor buildings on south-west side.

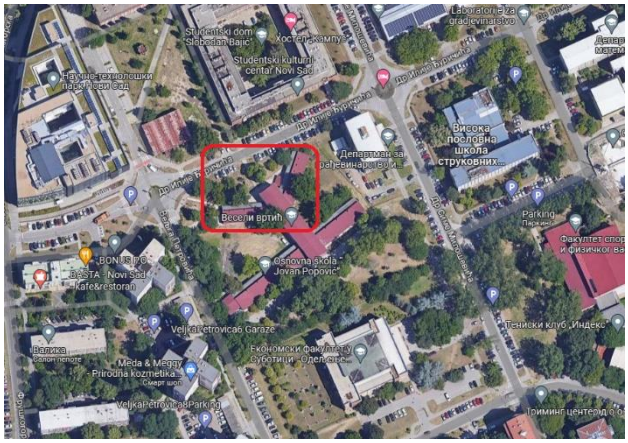

Fig. 5. Location of kindergarten “Veseli vrtic”.

The elementary school “Vuk Karadzic”, which is highlighted with red rectangle line in Fig. 6, is situated in a low-populated residential area of the city. It is surrounded by individual households in a very quiet street and with low intensity of traffic. Also, the location is bounded by the railway on the south side, additionally preventing circulation of the population and decreasing needs for an extensive coverage by the radio networks signal.

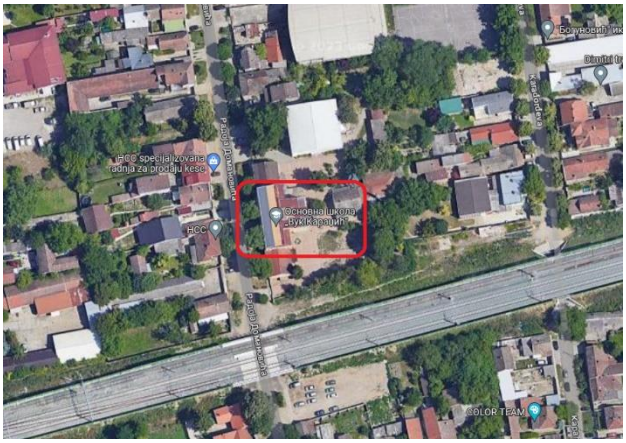

Fig. 6. Location of elementary school “Vuk Karadzic”.

B. Dissemination of acquired EMF results

At all considered locations, the AMB 8059 EMF sensors are installed, equipped with EP-1B-03 electric field probe. Regarding the kindergarten “Suncokret”, the sensor is positioned on the roof of the building, as partially shown in Fig. 7. It is located on the south-east corner of the building, close to the residential buildings, while details for other locations can be found on EMF RATEL Internet portal [7].

The sensors perform permanent measurements of the electric field strength, applying six-minute averaging, as required by standard EN 50413:2020 [14], which regulates the high-frequency field measurements and assessment of the human EMF exposure.

The acquired measurement results are published over the EMF RATEL Internet portal [7], as it is displayed in Fig. 7, for the case of the kindergarten “Suncokret”.

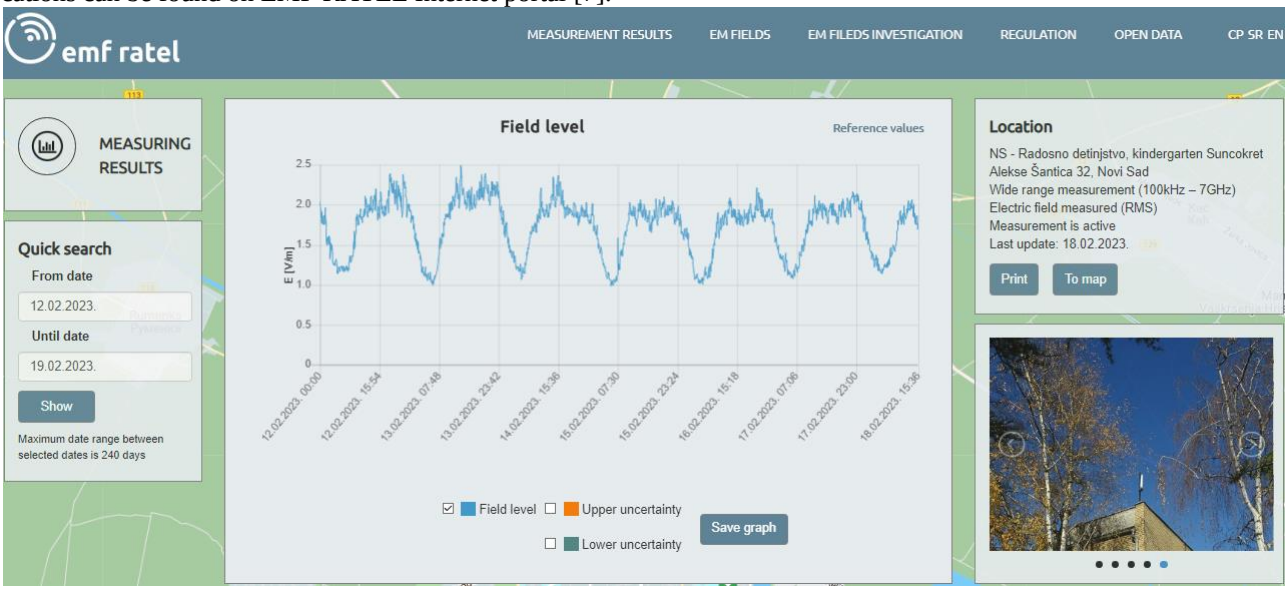

Fig. 7. Dissemination of EMF measurement results for the location of the kindergarten “Suncokret” [7].

The EMF RATEL Internet portal has numerous handy features, among which is the search option that allows the selection of a particular time interval [7].

The portal timeline graph shows daily field fluctuation, providing valuable information for the community about the existing EMF levels and happenings in the past.

IV. ANALYSIS OF EMF MEASUREMENTS

The EMF RATEL network, as one of the five most important EMF monitoring networks worldwide [15], can provide long-term monitoring, which is essential for the comprehensive field analysis.

Besides the time-line analysis, which is oriented only to one direction, additional investigation can be done, revealing hidden knowledge on EMF for considered location.

A. The weekly EMF behavior over locations

The sensors at kindergartens "Suncokret" and "Veseli vrtic" have been performing EMF monitoring since 2017, while the sensor on "Vuk Karadzic" since 2021. Sensors provide 240 field measurements (samples) per day, due to six-minute averaging [14], creating extensive data sets.

Regarding population's daily activities in urban areas, it is valuable to analyze changes of EMF during the whole week, to get deep understanding of field behavior and its balance with local environment.

By performing averaging over time on the field samples, on each day and over monitoring years, the EMF behavior on "Suncokret" location is gained and presented in Fig. 8.

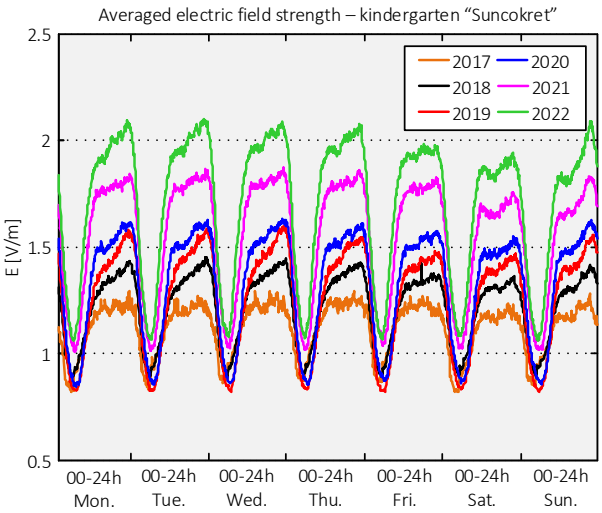

Fig. 8. EMF analysis for the kindergarten "Suncokret".

Similar analysis can be accomplished for two other locations, as shown in Fig. 9 and 10. However, for the location of "Vuk Karadzic" school only two full years and part of 2023 are presented, since monitoring started much later.

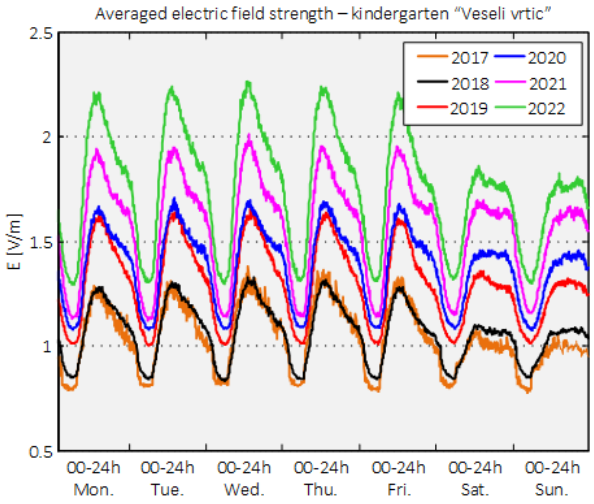

Fig. 9. EMF analysis for the kindergarten "Veseli vrtic".

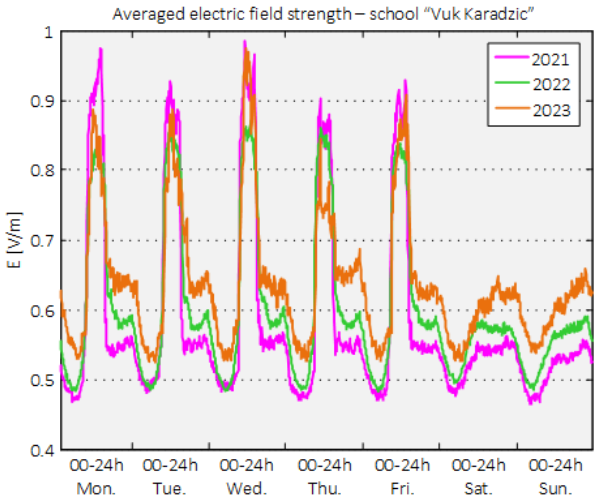

Fig. 10. EMF analysis for the school "Vuk Karadzic".

Many important details can be noticed from the presented graphs, among which is the periodicity of the field change, over working day, suggesting that similar levels of the electric field strength and its fluctuation exist almost every working day at all locations.

Also, the population density at each location has resulted in specific patterns of the field levels during working days and weekend.

Regarding location "Suncokret", the field levels are very similar over the whole week, while on "Veseli vrtic" and "Vuk Karadzic" locations, the clear difference between working days and weekend can be noticed.

This effect is particularly evident at the "Vuk Karadzic" location, where additional strong decrease of the field strength during night hours, can be observed.

However, the increase in the field levels occurring, from year to year, at all three locations, is what catches the eyes mainly. Although all acquired measurement results are far below the ICNIRP [5] and Serbian prescribed reference field levels (allowed electric field strength in Serbia are 2.5 times lower than ICNIRP levels, while the lowest allowed level is 11 V/m at 400 MHz) [16], the yearly increase of the field level should be carefully considered.

B. The field strength comparison among locations

Beside individual analysis of field strength at each location, the important comparison of field strength among locations can be completed, as depicted in Fig. 11, revealing additional hidden facts of field behavior.

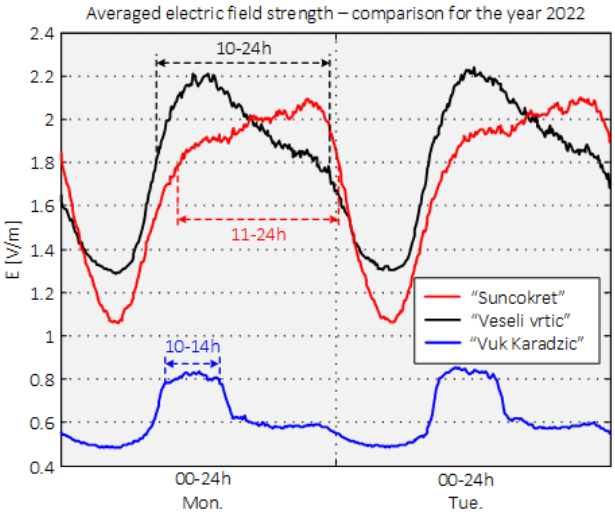

Fig. 11. Field strength per location.

To provide appropriate comparison, only year 2022 was selected. As a main outcome, the difference in field levels is evident at "Vuk Karazdic", the location with the lowest density of residential population, in comparison with the "Veseli vrtic", with medium density, and "Suncokret" with high density. The ration between the maximum measured field strengths is almost 2.5.

Also, the residential population density and activities in the area have their reflection on the time of the day with highest field strength and high levels duration, as noted in Fig. 11. For "Vuk Karazdic" school this period is relatively short, matching the time when most pupils leave/come to the school between noon and afternoon shift.

On the other hand, at "Suncokret" location, this period is extended almost to the midnight, with a slight increase in the field levels at night hours, while at the location of "Veseli vrtic", positioned between residential area and campus of the University of Novi Sad, this period is even one hour longer, with the rapid decrease of the field strength values in the afternoon and evening hours.

V. CONCLUSION

Because of population density, the city zones are regularly covered by appropriate radio network infrastructure, whose elements have influence on the levels of EMF and corresponding EMF exposure in the surroundings.

Using the continuous EMF monitoring of EMF RATEL network, the analysis of measurement data can reveal some important and hidden knowledge on EMF behavior in sensitive zones, as it is shown in a case study of two kindergartens and an elementary school of the city of Novi Sad.

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