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PB-28 [16:30]

Exposure of children living close to HV power lines and transformer substations to magnetic fields in Slovenia

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Keywords: Dosimetry (measurements), ELF/LF, Completed (unpublished)
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The purpose of the study was to obtain data on the personal exposure to extremely low-frequency (ELF) magnetic fields (MF) of 50 children under 18 years of age living near high-voltage power lines (PL) and transformer substations (TS) in different micro-environment settings in Slovenia.

Methods

Volunteers were invited to participate in the study by means of a public invitation through websites and various public events. Basic data on age and residence, distance from ELF MF sources and the consent of parents or guardian for participation were obtained from all volunteers/children. The distances from nearby ELF MF sources were additionally verified and supplemented based on the living address and the data from the registry of the sources of ELF MF.

Children included in the study were divided into three groups according to the distance from the ELF MF sources:

- PL group, which included children living less than 150m from the PL,
- TS group, which included children living less than 30m from the TS, and
- control group, which included children living neither near a PL nor near a TS.

Detailed instructions, a letter to the school with the explanation of the project and child's participation, as well as an activity diary were prepared to carry out personal exposure measurements. In the activity diary the participants recorded type of activities, microenvironment data and duration of each activity. The purpose of the questionnaire was to gather detailed information on individual exposure categories:

- Home - exposure of the volunteer in his home,
- School - exposure of the volunteer at school,
- Travel - exposure of a volunteer on the road when moving from one location to another regardless of the mode of movement (on foot, car, bus, train…),
- Outdoor - exposure of the volunteer at all outdoor activities,
- Miscellaneous - exposure of the volunteer in all other cases,
- Sleep - exposure of the volunteer during sleep.

At the end of the session, a questionnaire was completed for each participant to gather the data about measurements and devices used in everyday life, as well as other important data that could affect or influence the measurements and were later used in data analysis, such as e.g. the type of building where volunteer lives, the number of household members, the method of heating etc. Personal exposure measurements lasted at least 36 hours, during which time volunteers wore an Enertech EMDEX II personal exposimeter to measure ELF MF, a GPS logging device to store location, and the participant recorded current activities in the activity diary: Home, School, Travel, Outdoor, Miscellaneous and Sleep.

Prior to statistical analysis, all measurement data were reviewed. Based on past experience, it was expected that activity diary entries with information on individual child's activities. will contain certain errors, as children may forget to enter a new activity, enter an incorrect activity, or enter an activity at the wrong time. To detect and correct such errors, a special data processing tool was developed that provided a visual overview of GPS

measurement results (location and speed) in Google Earth. This enabled the correction of entries in the activity diary.

For statistical analysis the strongest permitted statistical tests (t-test, Mann-Whitney U, Kruskal-Wallis ANOVA) were used. In interpreting the statistical characteristics, we assumed a risk level $\alpha = 0.05$.

Results

Of the 50 participants, 15 children lived near PL, 16 near TS, 1 near both, and the other 18 did not live nearby PL or TS. Regarding the type of environment, 4 children lived in rural areas, 10 in small village, 10 in urban areas and 26 in large cities. Regarding the type of building, 22 children lived in a detached house, 2 in a terraced house, 2 in a semi-detached house, 13 in an apartment block with less than 20 apartments and 11 in an apartment block with more than 20 apartments.

The geometric mean values of the ELF MF of all participating children were 0.08μT for activity Home, 0.05μT for activity School, 0.07μT for activity Travel, 0.05μT for activity Outdoor and 0.06μT for activities Miscellaneous and Sleep. A more detailed statistical analysis of the data showed that there is a statistically significant difference in exposure of the PL and TS groups compared to the control group for activities Home, Outdoor and Sleep. The geometric mean value of ELF MF for activity Home was 0.13μT for the PL and TS groups and 0.04μT for the control group; for Activity Outdoor it was 0.08μT for the PL group, 0.05 μT for the TS group and 0.03μT for the control group; and for the activity Sleep it was 0.08μT for the group PL, 0.09μT for the group TS and 0.03μT for the control group.

The results in Figure 1 show that geometric mean MF values in the immediate vicinity of PL can be significant. The average 24-hour MF values for the case shown were also more than 1.5μT. However, elevated ELF MF values can also be caused by appliances located directly in the living environment. Figure 2 shows the results of measurements in a bedroom which is located next to the shaft with electrical cables in a multi-apartment building. Significantly elevated values of ELF MF during Sleep are visible for this exposure situation.

Table 1: Geometric mean values of ELF MF by activities for all children together and by activities for the DV group, the TP group and the control group. Statistically significant differences in average values for exposure at Home, Outdoors and Sleeping are highlighted in bold.

group	Geometric mean values	Home	School	Travel	Outdoor	Misc.	Sleep
all	the lowest for an individual child	0,01	0,01	0,03	0,01	0,01	0,01
	highest for an individual child	1,51	0,29	0,63	1,09	0,64	1,58
	all children	0,08	0,05	0,07	0,05	0,06	0,06
PL	the lowest for an individual child	0,01	0,01	0,03	0,03	0,01	0,01
	highest for an individual child	1,51	0,21	0,45	1,09	0,64	1,58

	all children	0,13	0,05	0,07	0,08	0,07	0,08
TS	the lowest for an individual child	0,03	0,02	0,01	0,03	0,03	0,01
	highest for an individual child	0,68	0,94	0,29	0,13	0,11	0,11
	all children	0,13	0,06	0,08	0,05	0,07	0,09
control	the lowest for an individual child	0,01	0,01	0,03	0,01	0,01	0,01
	highest for an individual child	0,46	0,27	0,63	0,23	0,39	0,35
	all children	0,04	0,04	0,06	0,03	0,05	0,03

Discussion

A more detailed statistical analysis of the measured values of ELF MF showed that there is a statistically significant difference between the exposure of the PL and TS groups compared to the control group. Statistically significant differences were shown for the activities Home, Outdoor and Sleep, i.e. in activities that took place at the location of permanent residence or in its vicinity.

The geometric mean value of the ELF MF for Home activity was 0.13μT for the PL and TS groups and 0.04μT for the control group; for the Outdoor activity 0.08μT for the PL group, 0.05μT for the TS group, and 0.03μT for the control group; and for the activity Sleep 0.08μT for the group PL, 0.09μT for the group TS, and 0.03μT for the control group.

As expected, the geometric mean B decreases with distance from the source. Although the trend is clear, deviations are expected to be large for individuals.

In addition to statistical analysis of the relationship between average exposure values of children and proximity to the source (PL, TS), other statistical analyses and verifications of relationships between data from personal exposure measurements and various data obtained with the questionnaire were performed, such as:

- the type of neighborhood where volunteer resides;
- the type of facility in which the volunteer resides;
- method of heating (electricity or other source);
- method of preparation of hot water (electricity or other source);
- number of household members.

In addition to the proximity to the source of ELF MF (PL, TS), statistically significant differences in children's exposure were found for the following factors:

- type of settlement (countryside, city), for the activity Travel: during the activity Travel, the group of children living in rural areas is statistically significantly more exposed;
- type of building (residential house, apartment block), for the activity Travel: during the activity Travel, a group of children living in an apartment block is statistically significantly more exposed;
- method of preparation of hot water (electricity, other source), for the activity Miscellaneous: in contrast to reasonable expectations, volunteers are statistically significantly exposed to higher ELF MF when

electricity in not used for the preparation of hot water.

The statistically significant difference due to the proximity of the source is understandable and clear, but there is no explanation for the remaining correlations in terms of possible causes for such differences.

Conclusion

The results of personal ELF MF exposure assessment show that children living near HV PL or near TS are statistically significantly exposed to higher ELF MF at home than children who do not live close to PL or TS.

The difference in the geometric mean values between groups PL and TS is quite small, taking into account that the average distance from powerlines in the PL group was 45m, while in the TS group half of the volunteers lived in an apartment near or just above the TS.

For the remaining half of the volunteers, the average distance of residence from the TS was less than 10m.

Figures

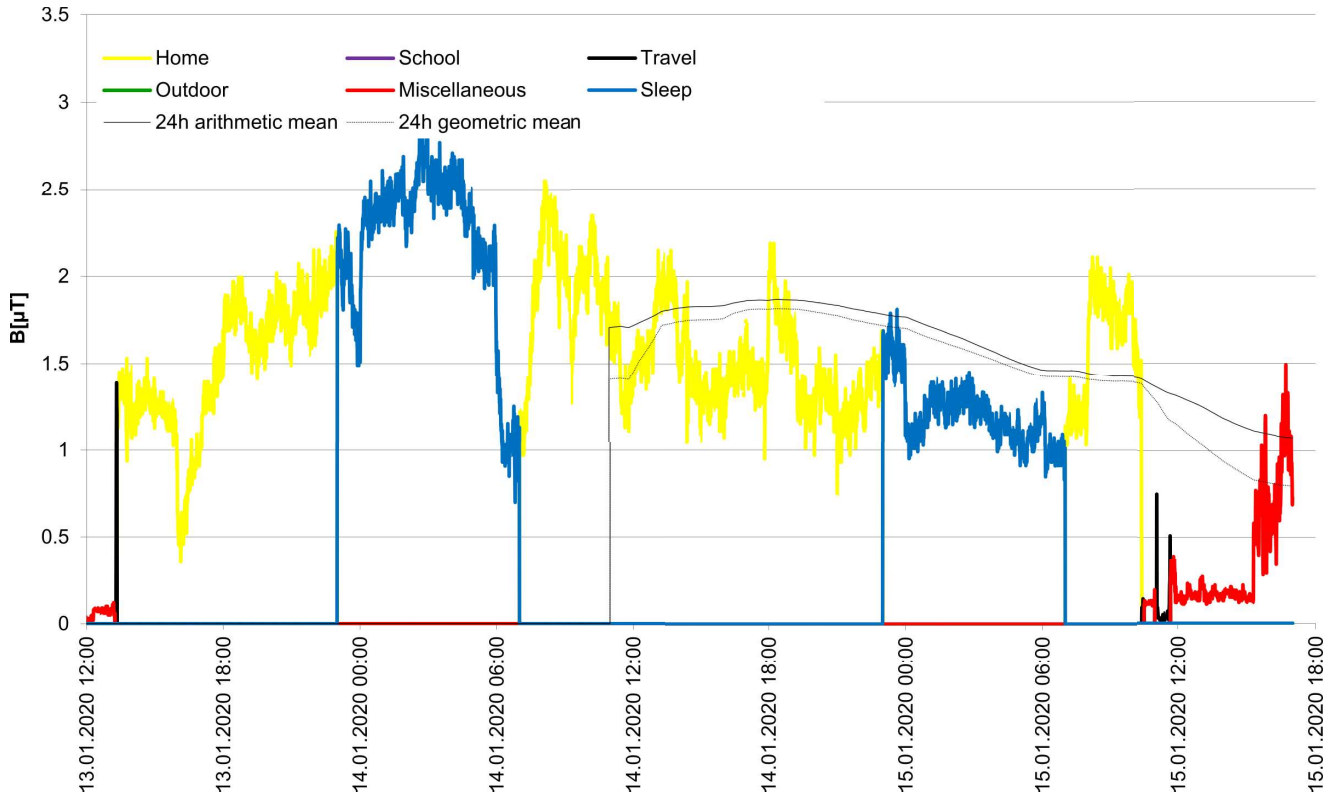

Figure 1. Results of the personal exposure measurements for a child living in the immediate vicinity of a 400 kV PL. Values in different exposure categories are presented in different colors.

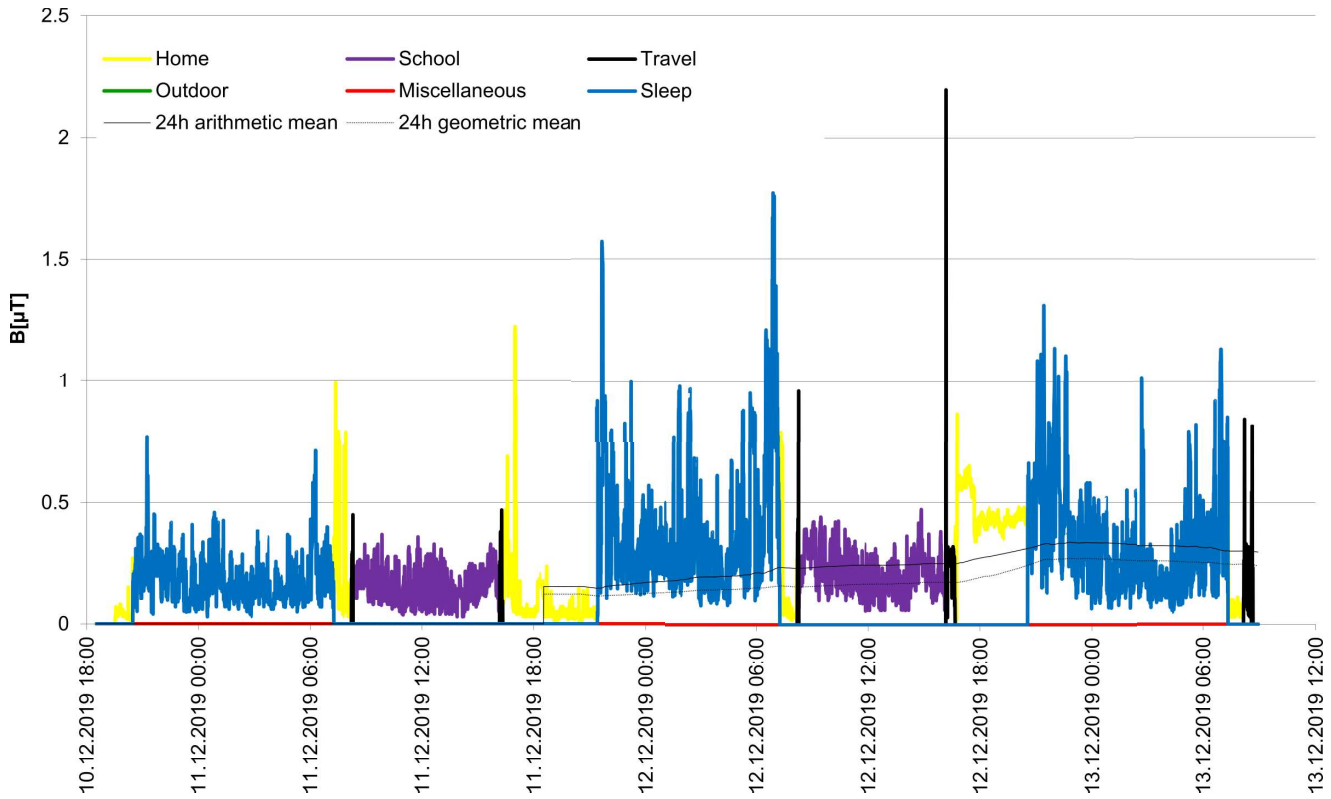

Figure 2. Results of the personal exposure measurements for a child living in a multi-apartment building where the bedroom is located next to the main electrical cables. Values in different exposure categories are presented in different colors.

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The study on the EMF measurement method of the reference signal in time domain for finding the maximum power of the 5G NR base station

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Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress
Presented by: Dong Geun Choi

In this paper, we are proposed the proper setting conditions with the ratio between VBW and RBW for measuring the 5G reference signal using spectrum analyzer in time domain. The measurement result can be affected by detector type and VBW and RBW setting ratio. As a result of comparing the three different types of equipment, we could get the similar results each other when the VBW was set equal to the RBW. We also got the same results when the VBW was set higher than the RBW. In conclusion, we are proposed that the VBW should either be equal to or higher than the RBW to avoid underestimation when spectrum analyzer use the RMS detector in zero span mode. It intends no VBW effect to the measurement in RMS mode.

Unlike existing LTE, 5G NR signals use beamforming technology that concentrates the electromagnetic field (EMF) to a specific point, so a new measurement method is needed because it was difficult to apply the channel power measurement based method due to 5G NR air interface behavior, especially TDD. For the measurement method, it is very important to find the point where the electromagnetic waves of the base