Evaluation of the Maximum Permissible Level of Low-Intensity Electromagnetic Radiation at Mobile Connection Frequency (1 GHz) by Changes in Motor Activity of *Spirostomum Ambiguum*

E. I. Sarapultseva, J. V. Igolkina, and A. V. Litovchenko

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 147, No. 4, pp. 411-413, April, 2009
Original article submitted August 20, 2008

Electromagnetic radiation at the mobile connection frequency (1 GHz) at maximum energy flow density (10 μW/cm^2) permitted in Russia causes serious functional disorders in the studied unicellular hydrobionts infusoria *Spirostomum ambiguum*: reduction of their spontaneous motor activity. The form of biological reaction is uncommon: the effect is threshold, overall, and does not depend on the duration of microwave exposure.

Key Words: *low-intense ultrahigh frequency radiation; spontaneous motor activity of one-cell invertebrate hydrobionts*

Mobile connection became now an integral component of human life. However, different opinions on the safety of electromagnetic field of mobile telephones are expressed, which is seen from differences in sanitary hygienic safety regulations recommended in different countries. In Russia, the maximum permissible level of microwave (MW) radiation is established at the level of 10 μW/cm^2, which is much more stringent than in Europe and the USA [4].

We studied maximum permissible level of low-intensity electromagnetic radiation (EMR) at the mobile connection frequency (1 GHz) by changes in spontaneous motor activity (SMA) of *Spirostomum ambiguum* (unicellular prenerve infusoria).

MATERIALS AND METHODS

The study was carried out on *Sp. ambiguum* infusoria. These large (1-3 mm long and 0.3-0.5 mm in diameter) infusoria could be observed at a negligible magnification (×2). The infusoria were kept in a mass culture in biological tubes at 20±1°C in tap water. Water was allowed to stay for at least 3 days and filtered through an ash-free filter. Once a week, the control and irradiated spirostomes were placed in a fresh portion of water for maintaining the culture in the log phase and nutrient yeast were added.

Low-intense MW-range EMR device used in our study is intended for exposure of living biological objects and water at a frequency of 1 GHz at 10 μW/cm^2 energy flow density. The device consisted of a narrow-band antenna, to which MW energy was delivered via a coaxial cable. P2-52 device for VSWR (voltage standing wave ratio) measurements consisting of an indicator block and control block with removable generators working in the permanent generation mode served as MW source. The frequency of 1 GHz belongs to not only mobile connection band, but also to the TV, radio, radiotelephone, and radiorelay connection bands.

Infusoria for irradiation were collected from the mass culture in the logarithmic growth phase 3 days after feeding. The exposure was carried out in plas-

Department of Biology, State Technological University of Atomic Energy, Obninsk, Russia. ***Address for correspondence:*** bioeco@iate.obninsk.ru. E. I. Sarapultseva

0007-4888/09/1474-0431

tic 3-cm Petri dishes in a 0.3 cm layer of water for 15, 30, 45 min, 1, 2, 3, 4, 6, 8, and 10 h. Control culture was placed under the same conditions behind a protective screen in order to rule out the effect of electromagnetic field. Directly after irradiation, changes in SMA were quantitatively evaluated in each experimental and control spirostome individually. According to methodological recommendations [2], each infusoria was placed into a special cuvette (8×2.5×0.5 cm) with cells 5 mm in diameter and 2 mm deep. Changes in SMA were evaluated by the number of crossover passages of the ocular viewfinder frame (MBS-10 microscope) within 1 min for each spirostome.

The study was carried out on 60 control spirostomes and 60 irradiated spirostomes after exposure of different duration as mentioned above (3 series). The results were processed using Student's test.

RESULTS

Changes in SMA in spirostomes exposed to MW radiation for 15 min to 1 h are presented in Table 1. A significant difference in comparison with the control manifested in a jumpwise manner after 30-min exposure.

Changes in SMA in 20 spirostomes in experimental series with 30-min exposure are presented in Fig. 1. All points in the experiment are below the mean basal values; hence, these changes are common.

Results of 3 experimental series with the threshold exposure of 30 min are presented. The mean SMA parameters in irradiated spirostomes were significantly lower than in the control (Table 2). These results are well reproduced in all experimental series, the mean difference from the control level being 35%.

The effect of longer MW exposure was studied in subsequent experiments. Changes in SMA directly after exposure are presented for a wide range of exposure periods (from 15 min to 10 h; Fig. 2). With prolongation of the exposure from 30 min to 10 h the differences between the experimental and control organisms were clear-cut and approximately the same. The effect caused by 30-min exposure did not increase significantly even after its 20-fold prolongation.

TABLE 1. Spontaneous Motor Activity of Spirostomes in the Control and Directly after MW Exposure for 15 min to 1 h at a Frequency of 1 GHz (Energy Flow Density 10 μW/cm²; *M*±*m*, *n*=60)

Duration of exposure	SMA, abs. units	Proportion of SMA in experiment to SMA in control, %
0 (control)	2.25±0.41	100.0±3.4
15 min	2.08±0.32	92.4±3.4
30 min	1.42±0.32*	63.1±6.2*
45 min	1.36±0.28*	60.4±6.3*
1 h	1.31±0.26*	58.2±6.4*

Note. Here and in Table 2: *p<0.05 compared to the control.

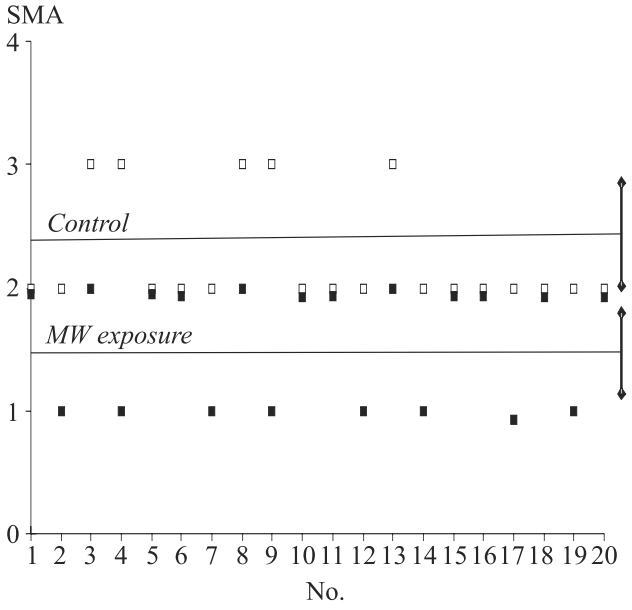

Fig. 1. Parameters of SMA in spirostomes in the control (light symbols) and experiment after MW exposure for 30 min (dark symbols). Protocol data.

TABLE 2. Mean SMA Values in Spirostomes in Control and after MW Exposure at a Frequency of 1 GHz for 30 min in 3 Experimental Series (*M*±*m*; *n*=20 per series)

Series	Control	Experiment	Proportion of SMA in experiment to SMA in control, %
1	2.18±0.46	1.36±0.41	62.4±10.8*
2	2.16±0.38	1.32±0.35	60.9±10.9*
3	2.31±0.36	1.49±0.28	64.6±10.7*
Mean	2.23±0.40	1.41±0.32	62.6±6.2*

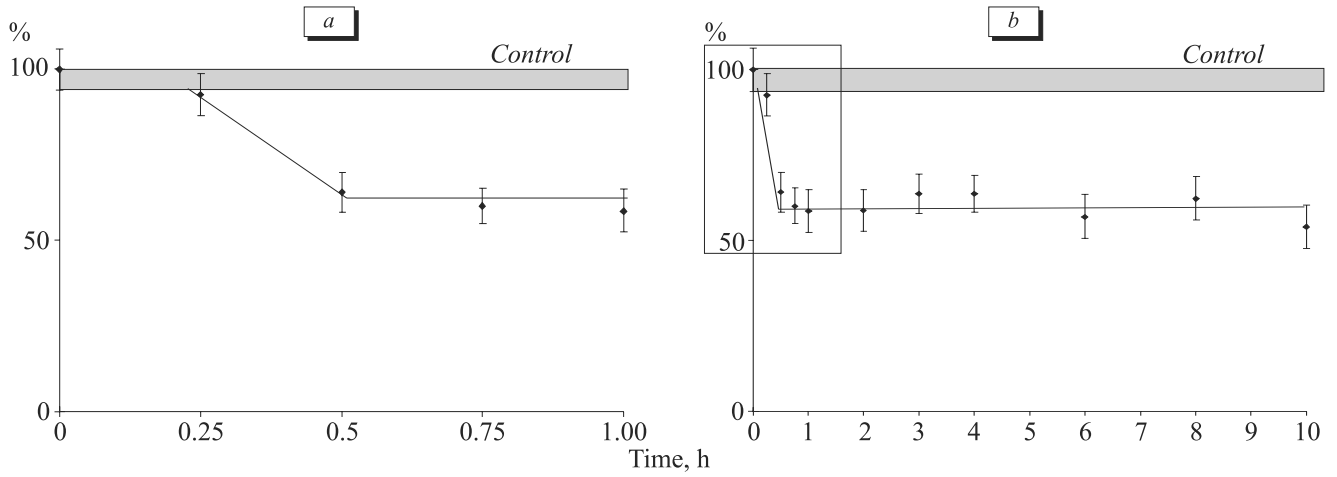

Fig. 2. Relationship between spirostome SMA (% of control) and duration of MW exposure at a frequency of 1 GHz (energy flow density 10 μW/cm^2) for 15 min to 1 h (*a*) and 15 min to 10 h (*b*).

Hence, we detected: a significant reduction of SMA in invertebrate hydrobionts (*Spirostomum ambiguum* infusoria) after low-intense EMR exposure at the mobile connection frequency; a threshold length of exposure; overall manifestation of changes and no relationship between the effect manifestation and duration of exposure for a wide range of periods. This form of reaction cannot be explained from common viewpoints.

However, our data are in line with published reports [1] on overall dose-independent effects in populations of other infusoria species (*Paramecium caudatum*, *Climacostomum virens*), amebas and mammalian cells after low-dose radiation exposure, and with our previous findings demonstrating dose-independent reduction of SMA in *Sp. ambiguum* after low-dose γ-irradiation [3]. The universal pattern of biological effects detected after exposure to different physical factors in organisms of different phylogenetic levels suggests a universal mechanism of the formation of the biological response to the external exposure. The mechanism of these changes remains unclear.

Our data on harmful effect of MW radiation at the mobile connection frequency suggest ecological hazards of low-intense MW radiation of nonthermal power and prompt evaluation of maximum permissible levels of radiation exposure of these kinds.

REFERENCES

1. I. B. Bychkovskaya, R. F. Fedortseva, P. V. Antonov, *et al.*, *Special Cell Effects and Somatic Aftereffects of Low-Dose Irradiation* [in Russian], St. Petersburg (2006).
2. O. P. Melekhova, E. I. Sarapultseva, T. I. Evseeva, *et al.*, *Biological Monitoring of the Environment: Bioindication and Biotesting. Training Aid*, Eds. O. P. Melekhova and E. I. Sarapul'tseva [in Russian], Moscow (2008), pp. 216-220.
3. E. I. Sarapul'tseva, *Radiats. Biol. Radioekol.*, **48**, No. 3, 346-348 (2008).
4. *Electromagnetic Fields under Industrial Conditions* [in Russian], SanPin 2.2.4.1191-03.