

Some new results on mobile phone radiation effect on *Lemna minor*

Kresimir Malaric¹, Mirta Tkalec², Roman Malaric¹

¹ Faculty of Electrical Engineering and Computing, Unska 3, HR-10000, Zagreb, Croatia,

² Faculty of Science, Department of Botany, Rooseveltov Trg 6, HR-1000, Zagreb, Croatia

Abstract-This paper is the continuation of the experiments with the mobile phone radiation effect on *Lemna minor*. Here, the effect of 217 Hz modulation with electric field strength of 23 V/m, 2 hours long exposure at the frequency of 900 MHz, was taken into the account. The results showed no statistical growth decrease. A peroxidase activity in exposed plants was slightly increased. Observed changes were small both for growth and peroxidase activity.

I. Introduction

Biomedical experiments are matter of extensive research for the last twenty or so years. They have been intensified lately due to the increased use of mobile phones, which have spread rapidly [1,2].

Mobile phones are using frequencies in the range from 400 to 1900 MHz and beyond. Cell phone radiation is non-ionizing; in other words it has not sufficient energy to break the chemical bonds of organic molecules. However, organic material can be heated by high power field generated by mobile phone in the range from 0.15 mW to 2 W. This could raise the temperature of the nearby cells from 0.1 to 1 °C. EMF generated by mobile phones or base stations could also change the cell membrane's permeability and cell growth rate and interfere with organic molecules like DNA and enzymes [3].

Plants are essential components of a healthy ecosystem and have important role in the living world as main primary producers of food and oxygen, therefore it would be beneficial to investigate their interaction today's EM environment. Only few investigations about effects of EMF on plants have been reported so far [4,5] but higher plants could be useful test organisms for environmental studies because they are eucaryotic multicellular organisms.

The GTEM-cell can be used to study the effect of EMF on living organisms. In this work the effect of EMF on *Lemna minor* growth has been studied as well as on the activity of peroxidase, a protective antioxidative enzyme whose activity changes under different environmental stresses [6,7].

II. Instrumentation

Gigahertz Transversal Electromagnetic Mode (GTEM)-cell (Fig.1.) is a transmission structure based on a TEM-cell approach [8]. The TEM mode excited by either a continuous wave source or a pulse generator simulates an incident plane wave for immunity and emission tests. Inside the GTEM-cell, the electromagnetic field is uniform and the plants were exposed to conditions similar to those of free space.

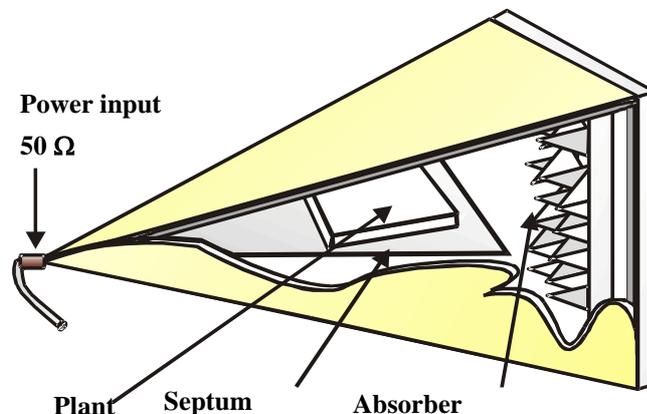


Fig. 1. GTEM-cell

Measurements were performed with HP 8657A signal generator and MiniCircuits 5W amplifier in a laboratory controlled conditions (temperature and humidity). The plants in plastic Petri dishes (diameter of 9 cm) were placed between septum and outer shield in the homogenous field as shown in the above figure..

III. Test organism

Lemna minor is the simple and small aquatic plant widely used as a test organism for environmental monitoring due to the numerous advantages. [9]. It has high vegetative reproduction rate and are easily grown in aseptic and controlled laboratory conditions.

Plants were exposed in the GTEM cell to the fields of 900 MHz and strength of 23 V/m for two four hours with the modulation of 217 Hz. There was no measurable temperature rise during the experiments. Five Petri dishes were used for each treatment as well as for control. Control plants were kept in the same growth conditions (room temperature, dark) as treated ones but outside the GTEM-cell (in field-free environment).

After exposure, individual plants were randomly picked out from Petri dishes and each plant was transferred in an Erlenmeyer flask with fresh nutrient solution for growth evaluation. For each treatment as well as for the control, seven replicates were prepared. Plants were counted on days 0, 3, 5, 8, 10, 12, 14 and relative plant number was calculated according to the following formula:

$$\frac{n_d - n_0}{n_0}, \quad (1)$$

where $d = 3, 5, 8, 10, 12, 14$ are the day numbers, n_d and n_0 are number of fronds at days d and 0 respectively. The results were given as mean of seven replicates and compared using Duncan's multiple range test.

Since peroxidases are well known biomarkers for plants exposed to different environmental stresses we made plant extracts immediately after the exposure as well as after 24 hours [6]. Total guaiacol peroxidase activity was determined spectrophotometrically at 470 nm and expressed as $\mu\text{mol}/\text{min}_{\text{gFW}}$ [7].

IV. Results

Exposure to electric field of 23 V/m at frequency of 900 MHz for two hours slightly decreased the growth at day 5, and further on slight decrease was noticed in comparison with the control but it was not significant (Fig. 2).

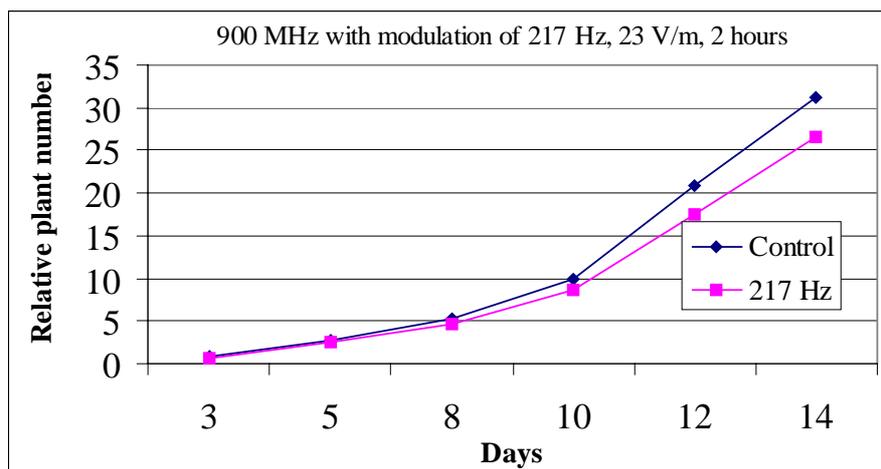


Figure 2. Relative plant growth after 2 hrs exposure to 900 MHz with modulation of 217 Hz, 23 V/m

In comparison with our previous results [10], where instead of 217 Hz we had 1 kHz sine modulation, growth decrease is much smaller in our case (217 Hz) than before (1 kHz sine). In GSM system, 217 Hz is the actual modulation used.

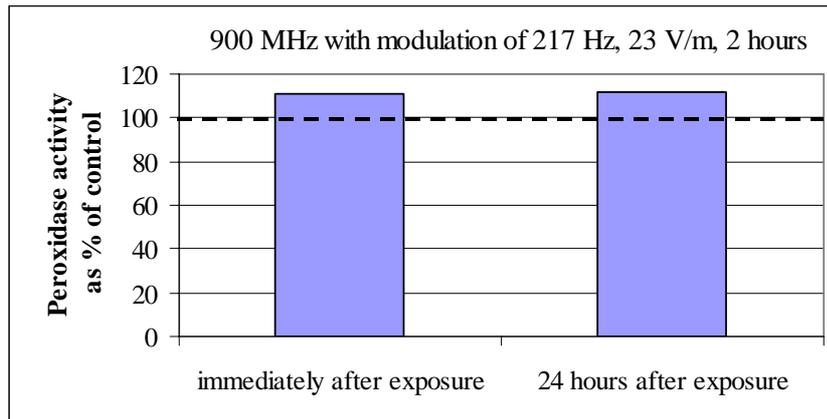


Figure 3. Peroxidase activity in plants exposed to 900 MHz with modulation of 217 Hz, 23 V/m for 2 hrs immediately after exposure and after 24 hrs. Control values are expressed as 100%.

As seen from Fig. 3. peroxidase activity was slightly increased (~10%) immediately after exposure as well as 24 hours after exposure to investigated field. Previous results with 1 kHz sine modulation also showed slight increase of peroxidase activity but only 24 hours after exposure.

V. Conclusions

GTEM-cell, designed at FER, Zagreb. could be used for biological exposures. Plant *Lemna minor* was exposed to the electric field of frequency 900 MHz with modulation of 217 Hz and strength 23 V/m for 2 hours Growth was slightly inhibited while peroxidase activity as biochemical marker of stress increased but the observed changes were rather small (around 10%).

References

- [1] J.C. Lin, "Microwave exposure and safety associated with personal wireless telecommunication base stations", *IEEE Microwave magazine*, September 2002.
- [2] M. Netzer, "Does radio frequency electromagnetic radiation (EMR) cause cancer?", *ITEM Update*, 2000.
- [3] S. Kwee, and P. Raskmark, "Changes in cell proliferation due to environmental non-ionizing Microwave radiation", *Bioelectrochem. Bioenerg.* 44, pp. 251-255, 1998.
- [4] I. Magone, "The effect of electromagnetic radiation from the Skrunđa Radio Location Station on *Spirodela polyrhiza* (L.)", *Sci. Total. Environ.* 180, pp. 75-80, 1996.
- [5] M. Muraji, T. Asai, and W. Tatebe, "Primary root growth rate of *Zea mays* seedlings grown in an alternating magnetic field of different frequencies", *Bioelectrochem. Bioenerg.* 44, pp. 271-273, 1998.
- [6] J.L. Peters, F.J. Castillo and R.L. Heath, "Alteration of extracellular enzymes in pinto bean leaves upon exposure to air pollutants, ozone and sulfur dioxide", *Plant Physiol.* 89, pp. 159-164, 1988.
- [7] M. Mäder, P. Münch and M. Bopp, "Regulation und Bedeutung der Peroxidase-Musteränderungen in sprossdifferenzierenden Kallus Kulturen von *Nicotiana tabacum* L. ", *Planta* (Berl.) 123, pp. 257-265, 1975.
- [8] D. Koenigstein and D.Hansen, "A New Family of TEM-Cells with Enlarged Bandwidth and Optimized Working Volume", *7th Zurich Symp. and Techn. Exh. on EMC, Proc.* pp. 172-132, March 1987.
- [9] M.A. Lewis, "Use of freshwater plants for phytotoxicity testing: a review", *Environ. Pollut.* 87, pp. 319-336, 1995.
- [10] Kresimir Malaric, Mirta Tkalec, Zeljka Vidakovic-Cifrek: "Mobile phone radiation effect on *Lemna Minor*", 6th International Congress of the European Bioelectromagnetics Association (EBEA), 13-15. November 2003, Budapest, Hungary, pp. 140.