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Impact of next-generation 5G cellular communications on honey bees

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Abstract. The article discusses the impact of ultra-high-frequency (microwave) radiation of a new generation of 5G networks on honey bees. It has been shown that alternating electromagnetic fields can have a harmful effect on bees. Exposure standards are considered, an analysis of the 5G electromagnetic radiation (EMR) effect on bees and methods of protection against exposure is carried out. The Specific Absorption Rate (SAR) value was calculated and it was concluded that the specific absorbed power is significantly less than the value causing the thermal effect on a honey bee. EMP protection can be provided by time, distance and shielding. An effective means of protection against the electromagnetic radiation effects is shielding of radiation sources using shields. When shielding high-frequency electromagnetic fields, the induced currents are concentrated near the screen surface; wherein at the penetration distance δ into the screen material the magnitude of components E and H decreases by 2.73 times. The results of calculating the efficiency of shielding bee hives from 5G EMR and energy flux density (EFD) inside bee hives showed the applicability of shields made of aluminum and steel to protect bees from 5G radiation.

1. Introduction

The study of the impact of non-ionizing electromagnetic radiation (EMR) of the radio range on biological objects is an urgent task, as with the technology development, territories of irradiation and number of irradiated objects increase. Recently, new communication standards have been introduced and widely implemented, for example, the fifth generation of 5G mobile communications. Next-generation 5G cellular communications are expected to deliver much faster data rates than existing 4G technologies. This will ensure widespread adoption of broadband mobile communications.

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But at the same time, it is worth noting the population concern of various countries with the spread and development of 5G networks. Disputes about the possible harm of 5G to public health due to the increase in exposure to high-frequency electromagnetic fields continue. Both in the scientific world and in society, the issue of the radiation impact generated with the help of technologies that are used in

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the deployment of 5G networks on the human body and on various biological objects has become acute.

In recent decades, the EMR influence on the vital activity of honey bees has been widely studied. The yield of agricultural plants depends on the pollination activity of honey bees. A decrease in the bee population can lead to a decrease in the food diversity for the majority of the population. Therefore, the effect of various EMR, including 5G bands, on the honey bee needs to be carefully studied.

In recent years, there has been a decrease in the number of bees due to extinction or death. The Greenpeace report 2013 found that insect mortality of the total population in Europe rose to 20 percent, and in some countries reached 53 percent. [1]

The reason for the death of bees is called global warming, the use of dangerous chemicals used by farmers, the destruction of the usual habitats of insects. The harmful effects of cell towers, including 5G bands, are also possible [2].

A.Stark and E. Berg in 1988 determined that alternating electromagnetic fields (EMF) of different frequency and intensity can have a harmful effect on bees, causing them anxiety and a sharp change in behavioral reactions. Therefore, it is not recommended to place hives near high voltage overhead power lines. Various studies show a decrease in flight activity, an increase in swarming propensity and propolis activity [3].

It has been established that bees have their own charge, their mechanisms of EMF perception are diverse and not fully understood. The EMF influence causes changes in the hive microclimate - temperature, gas composition and other parameters. Irradiation with a power of 70 W by UHF (ultra-high frequencies) waves of brood located outside the colony with voltage leads to its death [4].

Employees of the Swiss Federal University of Technology published a report on the electromagnetic waves influence on the life and development of bee colonies. As a result of long observations, it was revealed that the color spectra of magnetic fields impede the communication of bees in space.

Several bee colonies took part in the study during one season. Every day, the hives were exposed to 15 minutes of radiation. As a result, after three months the bees stopped producing honey, and the queen cut the reproduction of offspring in half. To protect bee colonies from destruction, scientists propose to stop using frequencies that disorient insects or to build bee farms at a great distance from cellular stations and base stations [4].

In 2016-2017 in the laboratory of I. P. Pavlov Institute of Physiology of the Russian Academy of Sciences showed that EMR impairs unconditional-reflex food excitability and short-term memory in a honey bee after irradiation with a WiFi router for 1 day [5].

Russian scientist A. Korzun suggested that "Colony Collapse Disorder" (collapse - complete decline), the moments when at the end of the autumn season hives with outwardly normal families suddenly find themselves without bees, caused by loss of orientation collecting bees due to interference with their navigation system and its death. To return to the hive, bees do not use visual navigation, but fly using physical fields [6].

2. Materials and methods

The 5G human exposure assessment considers the Specific Absorption Rate (SAR) generated in the user's head when using a mobile phone. SAR information can be a criterion for extrapolating and comparing experimental results for various tissues of humans and biological objects.

The calculation of the SAR value [W/kg] is based on the calculation of the electric field E [V/m] from the following ratio:

$$\mathrm{SAR} = \frac{\sigma|\mathrm{E}|^2}{\rho} \tag{1}$$

where σ is material conductivity in a given volume, S/m;

E is field strength, V/m;

ρ is specific density of the substance, kg/m^3.

The comparison of the obtained value is carried out with the guideline value, which for humans is based on the standards developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the IEEE International Committee on Electromagnetic Safety and is 1000 μW/cm^2 [7-8]. For Russia, a more stringent norm is set – 10 μW/cm^2, which in the microwave range corresponds to a specific absorbed power (SAR) of 4 W/kg mass [9].

Electromagnetic interference (EMI) protection is provided by time, distance and shielding. An effective means of protection against the electromagnetic radiation effects is the shielding of radiation sources using screens that absorb or reflect electromagnetic energy [10]. It is proposed to install protective screens in order to reduce the energy flux density (EFD) level near the bee hives.

The efficiency of thin metal screens as a whole depends on the ratio of the screen thickness d to the penetration distance δ, which is determined by the relation:

$$\delta = \sqrt{\frac{\rho}{\pi f \mu}}, \text{m} \quad (2)$$

where ρ is the resistivity of the screen material, Ohm·m;
μ is the magnetic permeability of the screen material, H/m;
f is frequency, Hz [10].

The efficiency of a metal shield is determined by the following formula:

$$E = 36 + 20\lg(\delta/\rho) + 8{,}7(d/\delta), \text{ dB} \quad (3)$$

The efficiency of the screen due to the reflection from the screen in formula (3) determines the first two terms, the efficiency of shielding due to the absorption of EMR in the screen material is determined by the third term.

When conducting experimental studies, the shielding efficiency is determined after measurements by the formula:

$$E = 10 \lg (PPE1/ PPE2), \text{ dB} \quad (4)$$

where PPE1 is the value of EFD in front of the screen;
PPE2 is the value of EFD after the screen.

After determining the calculated shielding efficiency, knowing the value of PPE1, we can calculate the value of PPE2 according to the expression:

$$PPE2 = PPE1 \cdot 10\text{-}0.1E, \ \mu W / cm^2 \quad (5)$$

When shielding high-frequency EMF, the induced currents are concentrated near the shield surface (skin effect phenomenon). The penetration distance δ of the field into the screen material is the distance along the EMF propagation, at which the values of components E and H decrease by 2.73 times. Part of the incident energy is reflected from the screen, part is absorbed and part passes through the screen (according to the wave theory of the electromagnetic field).

3. Results

The aim of the study is to examine the effect of 5G EMR on honey bees and to analyze ways to protect against 5G EMR. Microwave energy, including the 5G range, penetrating into living tissues, is dissipated in the form of heat, which is absorbed by the body. The amount of energy absorbed depends on the frequency of this signal.

The calculation showed that the SAR value for the bee is 0.4 mW. The weight of the bee was chosen for the calculation equal to 0.1 g [11-13]. Taking into account the current capacities of the new generation 5G cellular base stations, reaching 50 W, the value of the SAR is significantly lower than the value that causes the thermal effect on the honey bee.

The results of calculating the efficiency of shielding bee hives from EMR of the 5G range and EFD inside bee hives are presented in table 1. The material of the screens has been chosen such common metal materials as aluminum and stainless steel. The calculation was carried out for two characteristic frequencies – 3.5 GHz and 27.3 GHz. The selected materials fully shield the 5G EMR.

Table 1. Calculation of protective screens in order to reduce the level of EFD near bee hives.

Material	resistivity ρ, Ohm·m	magnetic permeability μ, H/m	Э, dB		PPE2, μW / cm^2	
			3.5 GHz	27.3 GHz	3.5 GHz	27.3 GHz
Aluminum	$2.7 \cdot 10^{-8}$	$1.26 \cdot 10^{-6}$	7548	20941	0	0
Stainless steel	$7.5 \cdot 10^{-8}$	$10 \cdot 10^{-3}$	52693	147086	0	0

4. Discussion

The SAR calculations were carried out for the norms established for the impact on humans. When assessing the impact on honey bees and other biological objects, it is necessary to take into account the biological reserve coefficient.

When calculating the screening efficiency of bee hives, aluminum and steel were taken as the material for the screen, but this does not take into account the economic effect, so additional calculations are required. It is also necessary to take into account the weakening of the Earth's geomagnetic field, which can negatively affect the condition and vital activity of honey bees.

5. Conclusion

The performed calculation showed the applicability of screens made of aluminum and steel to protect bees from 5G radiation. Protection by distance is also possible, that is, a long distance from base stations, including stations of the 5G range.

Further research should be carried out taking into account the biological reserve coefficient, taking into account the difference in the structure of honey bees and other biological objects, including humans.

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