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## ASSESSMENT OF THE EFFECT OF ELECTROMAGNETIC RADIATION FROM CELL PHONES USING THE *DAPHNIA MAGNA* TEST OBJECT

Currently, the problem of electromagnetic safety of the population has acquired social significance and is an urgent issue for the modern development of the Republic of Kazakhstan, as well as for other countries of the world. Environmental exposure to radiofrequency electromagnetic fields from mobile phones has rapidly increased in the last two decades and this trend is expected to continue. Modern technologies have become a source of electromagnetic pollution generated electromagnetic fields. Due to the increase in technogenic processes and their influence on the Earth's electromagnetic field, the topic of the influence of electromagnetic radiation on living organisms has been increasingly studied. All sources of electromagnetic fields, as a rule, are a source of complex electromagnetic radiation that affects plants, animals, insects and soil flora in the zone of influence of electromagnetic fields.

The effect of the electromagnetic fields emitted from cell phones on living organisms and human health have become one of the most important topics for research because cell phones are widely used all over the world. In many countries, cellular communication occupies a special place among anthropogenic sources of electromagnetic radiation. A cell phone is a small-sized transceiver operating in the 900/1800 MHz range, which refers to damaging environmental factors.

The influence of electromagnetic radiation of cell phones on the abundance of *Daphnia magna* was investigated. Radiation effects are clearly evident in the toxicology study with Samsung Galaxy J7 and Vivo V 20 cell phones. During the experiment, the radiation of these models of cell phones was established, and the abundance under the influence of Vivo V 20 was higher than under the influence of Samsung Galaxy J7, but lower than in the control group.

**Key words:** electromagnetic radiation, electromagnetic fields, cell phone, *Daphnia* culture, amount, hydrobionts.

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### Ұялы телефондардың электромагниттік сәулеленуінің әсерін *Daphnia magna* сынақ объектісі арқылы бағалау

Қазіргі уақытта халықтың электромагниттік қауіпсіздік проблемасының әлеуметтік маңыздылығы Қазақстан Республикасының, сондай-ақ әлемнің басқа елдерінің қазіргі дамуы үшін өзекті мәселесі болып табылады. Соңғы екі онжылдықта ұялы байланыс жасаған радиожилікті электромагниттік өрістердің қоршаған ортаға әсері артып келеді және бұл үрдіс жалғасады деп күтілуде. Пайда болған электромагниттік өрістерден қазіргі заманғы технологиялар электромагниттік ластану көздеріне айналды. Техногендік процестердің күшеюіне және олардың Жердің электромагниттік өріс әсеріне байланысты электромагниттік сәулеленудің тірі организмдерге әсері тақырыбы зерттелуде. Электромагниттік өрістердің барлық көздері, әдетте, электромагниттік өрістердің әсер ету аймағындағы өсімдіктерге, жануарларға, жәндіктерге және топырақ флорасына әсер ететін күрделі электромагниттік сәулелену көзі болып табылады.

Ұялы телефондар шығаратын электромагниттік өрістердің тірі организмдер мен адам денсаулығына әсері зерттеу үшін маңызды тақырыптардың бірі болды, өйткені ұялы телефондар бүкіл әлемде кеңінен қолданылады. Көптеген елдерде электромагниттік сәулеленудің антропогендік көздерінің арасында ұялы байланыс ерекше орын алады. Ұялы телефон 900/1800 МГц диапазонында жұмыс істейтін шағын габаритті қабылдағыш және ол қоршаған ортаны зақымдайтын факторлардың бірі болып саналады.

Ұялы телефондардан болатын электромагниттік сәулеленуінің *Daphnia magna* санына әсері зерттелді. Электромагниттік сәулеленудің әсері Samsung Galaxy J7 және Vivo V 20 ұялы телефондарының әсерінен токсикологиялық зерттеуде айқын көрінеді. Эксперимент кезінде

ұялы телефондардың осы модельдерінің сәулеленуі анықталды және Vivo V 20 әсер еткен кезде олардың саны Samsung Galaxy J7 әсеріне қарағанда жоғары болғандығы, бірақ бақылау тобымен салыстырғанда төмен болғандығы анықталды.

**Түйін сөздер:** электромагниттік сәулелену, электромагниттік өрістер, ұялы телефон, дафния мәдениеті, популяция саны, гидробионттар.

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### **Оценка влияния электромагнитных излучений сотовых телефонов с помощью тест-объекта *Daphnia magna***

В настоящее время проблема электромагнитной безопасности населения приобрела социальную значимость и является актуальным вопросом для современного развития Республики Казахстан, а также для других стран мира. За последние два десятилетия растет воздействие радиочастотных электромагнитных полей, создаваемых мобильной связью, на окружающую среду и ожидается, что эта тенденция сохранится. Современные технологии стали источниками электромагнитного загрязнения, излучающими электромагнитные поля. В связи с усилением техногенных процессов и их влияния на электромагнитное поле Земли все больше изучается тема влияния электромагнитного излучения на живые организмы. Все источники электромагнитных полей, как правило, являются источником комплексного электромагнитного излучения, которое оказывает воздействие на растения, животных, насекомых и почвенную флору в зоне влияния электромагнитных полей.

Влияние электромагнитных полей, излучаемых сотовыми телефонами, на живые организмы и здоровье человека стало одной из самых важных тем для исследований, так как сотовые телефоны широко используются во всем мире. Во многих странах среди антропогенных источников электромагнитных излучений особое место занимает сотовая связь. Сотовый телефон представляет собой малогабаритный приемопередатчик, работающий в диапазоне 900/1800 МГц, который относится к повреждающим факторам внешней среды.

Исследовано влияние электромагнитного излучения сотовых телефонов на численность *Daphnia magna*. Эффекты излучения четко выражены в токсикологическом исследовании воздействия сотовых телефонов Samsung Galaxy J7 и Vivo V 20. В результате эксперимента было выявлено излучение данных моделей сотовых телефонов, при этом влияние Vivo V 20 было выше, чем при воздействии Samsung Galaxy J7, но ниже чем в контрольной группе.

**Ключевые слова:** электромагнитные излучения, электромагнитные поля, сотовый телефон, культура дафний, численность, гидробионты.

## **Introduction**

Living organisms, both plants and animals, exist under the constant influence of the environment through environmental factors. Sustainable development of each country affects the quality of life and human health, which depends on the state of the environment, the quality of food and drinking water [1-3].

Currently, a large amount of data has been accumulated indicating the adverse effect of electromagnetic fields on biological objects [4-7]. The electromagnetic field, as a factor of production and the environment, is a risk factor for human health [8, 9]. New technologies have dramatically changed the biotechnological environment, thereby bringing EMF sources closer to living objects.

The ecological significance of electromagnetic fields is dramatically increasing in the modern world and is becoming the subject of special study [10].

In 1995, the World Health Organization (WHO) coined the official term “global electromagnetic pollution of the environment.” WHO pays special attention to the problem of negative effects of electromagnetic fields. WHO has included the problem of electromagnetic pollution of the environment among the priority problems of mankind [11]. In recent decades, many researchers studied the impact of an environmentally unfavorable environment on the physical development and functional state of the human body. It should be noted that negative factors of anthropogenic impact contribute to a decrease in health resources at the individual and population levels. As it has been argued by some researchers consider data that each ecological situation contributes to the formation of a certain phenotype [12].

Having entered our lives in parallel with rapid developments in technology, electronic devices have facilitated our lives and brought some health problems due to the electromagnetic fields they

emit. Research on the influence of electromagnetic fields on human health is of considerable interest. It must be underlined that the negative factors of anthropogenic impact contribute to a decrease in health resources at the individual and population levels. Among the sources of technology-related impact of electromagnetic radiation on the population, the most common are cell phones [13-15].

In the research of O.V. Vorob'yeva and her co-authors the effects of continuous and amplitude-shift-keying low-intensity EMF of the 10-m range with on-off cycling on fertility, offspring quality, and linear body size was studied in the planktonic crustacean *Daphnia magna*. Single exposure of 1-day-old crustaceans was shown to affect their reproductive characteristics, causing fetal abnormalities in the offspring and the linear dimensions of the body [16].

V. Krylov in his studies used the developing parthenogenetic eggs of *Daphnia magna* as a test system to assess the impact of a number of low-frequency electromagnetic fields with a density of 75  $\mu$ T. Two blocks of EMF acting frequencies were found in the studied series – 45, 110, and 175Hz, and 435 and 500Hz. The developing parthenogenetic eggs of *Daphnia magna* exposed to EMF with the indicated parameters showed an accelerated rate of embryonic development. Females that developed from open eggs showed productivity deterioration in the first brood [17].

In their work El-Maleky and his co-authors revealed an increase in the level of hepcidin with a subsequent deterioration in iron parameters during chronic exposure to EMF of mobile phones. The authors studied the effect of EMF action of phones of different durations on hematological parameters and the level of serum hepcidin in male rats [18].

L. Aleksandrova and her co-worker presented results of the impact of AMF in the immunogenesis organs (thymus, lymphoid formations in the intestine, somatic lymph nodes). It was established that the morphologic changes in the central and peripheral lymph organs of rabbits upon single and repeated (chronic) exposure to anthropogenous electromagnetic fields are of different nature [19].

Tamoyoki Shirai and his colleagues conducted a study in which pregnant rats and their newborn offspring were exposed to communication signals from various electromagnetic radiations. Thirty-six pregnant 10-week-old Sprague-Dawley rats were divided into three groups of 12 rats. They were control and two experimental groups. The entire body of mother rats was exposed to RF-EMF for 20 hours per day from the 7th day of gestation to wean-

ing. The offspring rats were exposed up to 6 of age weeks for 20 hours a day. No deviations from the norm were observed in either females or offspring of F1 exposed to RF EMF, or in offspring of F2 for any of the parameters assessed. As a result, under the conditions of that experiment, the simultaneous exposure of the whole body to eight different EMF communication signals at frequencies from 800 MHz to 5.2 GHz did not have any adverse effect on pregnancy or development of rats [20].

In the studies of Morioka Y and her co-authors, the effect of high-frequency electromagnetic radiation on cells in vitro was examined. Rat's fibroblasts were cultured and exposed to continuous frequency wave from mobile phones for 5 days. The results of their experiments showed an insignificant effect of the EMF of a cell phone with a power of 10 W/m<sup>2</sup> at 800 MHz on cell polypheration and destruction. The results also indicate the possible influence of the electromagnetic wave on cell arrangement and protein synthesis in cells [21].

E. I. Sarapultseva and her colleagues analyzed the result of direct and transgenerational effects of RF-EMF on the model organism of crustaceans *Daphnia magna*. The cytotoxicity of exposure as well as survival, fertility and teratogenic effect of directly exposed daphnids and their progeny across three generations were analyzed. The results of study showed that exposure of RF-EMF at juvenile period can significantly affect the fertility and size of irradiated daphnids and their offspring of the first generation. The decrease in fertility may be associated with a cytotoxic effect on the cells of irradiated animals [22].

Despite the fact that there are various studies devoted to the influence of EMF on living organisms, a lot of aspects are not sufficiently studied. In recent years, attention has been drawn to experiments on aquatic organisms for the toxicological assessment of this physical factor [23, 24]. Currently, much attention is paid to risk assessments and biological effects of electromagnetic radiation in biota. *Daphnia* are one of the most used test objects when studying the influence of external environmental factors on aquatic organisms, especially in toxicological studies.

We have studied the effect of electromagnetic radiation from cell phone on the course of germination of Siberian spruce's seeds and the growth dynamics of seeds' seedlings in the laboratory conditions. For the test version, the cell phone Samsung S3 (SAR 0.34) was used as a permanent source of radiation. as a result of the conducted research, the effect of the stimulating effect of the electromag-

netic radiation of a mobile phone on the growth of seedlings of Siberian spruce has been reliably established [25].

In this work, the aim of this research was to study the effect of electromagnetic radiation of cell phones Samsung Galaxy J7 and Vivo V20 on the amount of *Daphnia magna*.

### Materials and methods

It is advisable to study the effect of ultra-low doses of various substances on biological objects using a test object such as daphnia. The experiments were carried out on crustaceans of the species *Daphnia magna*. The crustaceans of the species *Daphnia magna* are larger and their use in toxicological experiments is preferable. The indicators of the life activity of crustaceans, which include mortality, fertility, and the anomalies in the offspring, have great importance for researchers. Experiments with daphnia must be carried out in a room free of chemical volatile substances.

In the experiments it was used crustaceans *Daphnia magna* grown at a laboratory under standard conditions. 200 ml of non-chlorinated water was poured separately in 3 beakers with a capacity of 500 ml. From the start of the experiment, 4 specimens of a mature daphnia species were placed

in each container at a temperature of  $21 \pm 2^\circ\text{C}$ . Each beaker was placed in a separate room, where they were influenced by cell phones. Irradiation with cell phones was carried out from the upper side of the experimental glasses with crustaceans. Cell phones Samsung Galaxy J7 and Vivo V20 were used as a radiation source.

The experiment took 21 days. From day 3, the results were recorded. In addition, on the day of the tests, the aquatic organisms were fed with cultures of 2 ml of green algae (*Chlorella* sp).

In the experiment, to identify the effects of radiation, observations were made over the control group, as well as under the influence of Samsung Galaxy J7 and Vivo V20 cell phones. 4 large individuals were seated in 3 glasses: the control group was not irradiated, while the second group was irradiated with a Samsung Galaxy J7 cell phone, and the third group was irradiated with Vivo V20 (table 1). During the experiment, the control group did not receive any dose of electromagnetic radiation, the second group was exposed to the ringing of a Samsung Galaxy J7 cell phone for 10 minutes, every 10 minutes; the third group consisted of daphnia, which were exposed to the ringing of the Vivo V20 cell phone for 10 minutes, every 10 minutes. The total irradiation time of crustaceans was 3 hours in a silent mode [26].

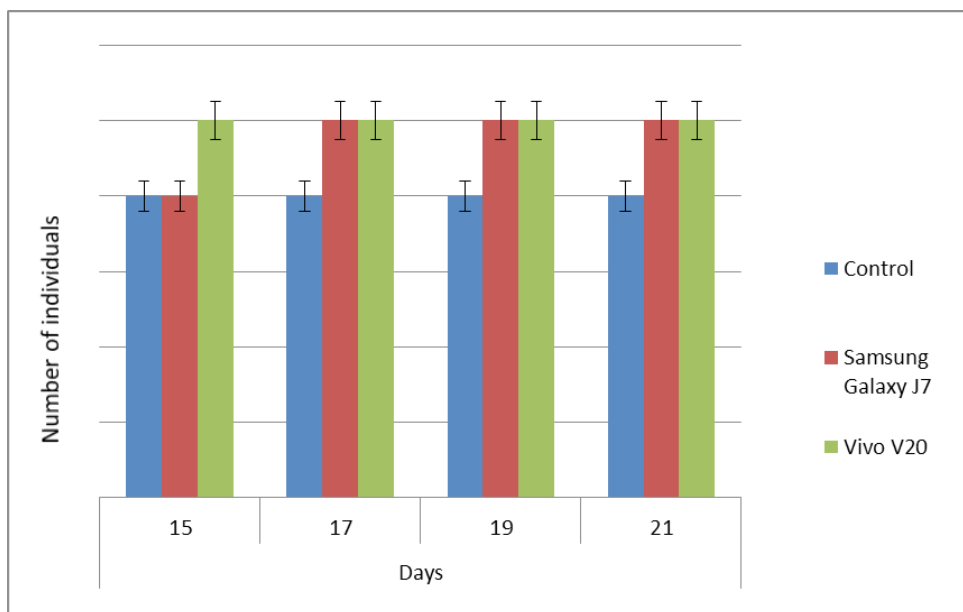
**Table 1** – The scheme of the experiments

Groups	Control group	Under the irradiation of Samsung Galaxy J7	Under the irradiation of Vivo V20
Number of experiments	3	3	3
Number of <i>Daphnia magna</i>	4	4	4
Duration, hours	3 hours	3 hours	3 hours
Exposure	10 minutes	10 minutes	10 minutes
Break	10 minutes	10 minutes	10 minutes
Mode	silent	silent	silent

### Results and Discussion

The results of the survey revealed that under the conditions of this experiment, changes in growth occurred in all groups. During the work, it was found that when exposed to electromagnetic radiation from cell phones Samsung Galaxy J7 and Vivo V20, the development of daphnia does not result in a decrease in their survival.

The experiment showed that large crustaceans, compared with the control group, demonstrated changes in the abundance on the 15th day after exposure to the Vivo V20 phone, and on the 17th day after irradiation with the Samsung Galaxy J7 phone, the difference of a delay of 2 days did not affect the total amount on the 21st day. Thus, during the study, the following values were obtained (Fig. 1).



**Figure 1** – Change in the number of large individuals of *Daphnia magna* after irradiation with Samsung Galaxy J7 and Vivo V20 phones

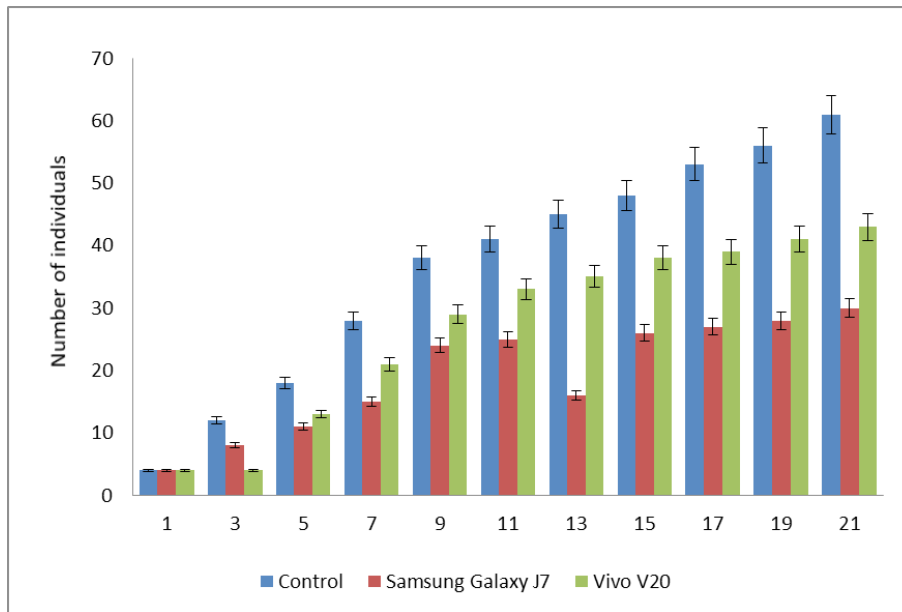
The observed values are changes in the growth of daphnia. At the beginning of the experiment, large crustaceans remained in number, but on the 15th day under the influence of the Vivo V20 cell phone there was an increase. The same happened on the 17th day under the influence of the Samsung Galaxy J7 phone. This indicates that electromagnetic fields contribute to a change in the population of aquatic organisms.

Further in the work, the changes in number of young daphnia exposed to electromagnetic radiation were investigated. Irradiation of young crustaceans under the conditions of this experiment has little effect on their amount: the decrease in growth is higher when exposed to the Samsung Galaxy J7 phone from the control level, and when irradiated with the Vivo V20 model, the decrease was even less. Data on the effect of irradiation on the fertility of daphnia during 21 days of observation is presented in Fig. 2.

The experiment revealed that exposure to the Samsung Galaxy J7 phone resulted in decrease of 33% on the 3rd day, and 41.2% on the 21st day; while a significant decrease of 63% occurred on the 13th day. Also, the crustaceans exposed to the Vivo

V20 showed decrease of 66.7% on the 3rd day, and 29.5% on the 21st day. It was also noted that under the influence of the Samsung Galaxy J7, the number of young crustaceans decreased more than in the control group and the group exposed to the Vivo V20 model.

In the course of the experiment, it was established that the irradiation of the Samsung Galaxy J7 cell phone led to the growth of daphnia on days 2-21, while the irradiation of the Vivo V20 phone resulted in higher growth of daphnia, but both groups showed less growth than the control one. The amount of growth of 2-7 days old crustaceans was 8 under the influence of the Samsung Galaxy J7, while this value in the Vivo V20 group was 6.64. On days 8-13, the amount of growth was 16.3 in the Samsung Galaxy J7 group, and with the Vivo V20 phone, this figure was 8.97. The group of 14-21 days old crustaceans showed the amount of growth of 26.75 under the influence of the Samsung Galaxy J7. In the same age group, the amount of growth was 0.84 under the influence of Vivo V20. A more detailed consideration of the dynamics of the number of young crustaceans is given in table 2.



**Figure 2** – Growth of young *Daphnia magna* under the influence of Samsung Galaxy J7 and Vivo V20 cell phones

**Table 2** – The amount of *Daphnia magna* in an EMF study exposed to Samsung Galaxy J7 and Vivo V20 cell phones

Age of the irradiated crustaceans	Control group	Under the influence of Samsung Galaxy J7	Under the influence of Vivo V20
1 day old	4±0,01	4±0,03	4±0,05
2-7 days old	19,3±0,035	11,33±0,14*	12,66±0,348*
8-13 days old	41,3±0,14	25±0,408*	32,33±0,125*
14-21 days old	54,5±0,192	27,75±0,603**	53,66±0,553

Note – \* – p< 0,05; \*\* – p< 0,01; \*\*\* – p< 0,001 compared with control species

The results show that electromagnetic radiation has an impact on daphnia abundance, with the Vivo V20 having a higher impact on daphnia growth than the Samsung Galaxy J7. The results of the study showed that the irradiation of cell phones provided the reliable data on its effect on the number of crustaceans *Daphnia magna*. The only minor exception was the group that was exposed to the Vivo V20 phone on days 14-21.

### Conclusion

The literature references show that electromagnetic radiation is manifested when certain parameters of radiation and the physiological state of living objects coincide, which determines its sensitivity to the action of radiation. Thus,

according to the above changes, it can be noted that the results of the experiment with daphnia do not allow us to assert the negative effect of electromagnetic radiation, since under the influence of the Samsung Galaxy J7 and Vivo V20 phones, the growth of daphnia occurred. Based on the results of the growth dynamics of aquatic organisms for 21 days, the influence of the cell phones frequencies on the growth rates of aquatic organisms can be clearly established. All 3 variants demonstrated the increase in the number of crustaceans. However, when exposed to the Samsung Galaxy J7, the number of daphnia was lower. In general, the experiment indicates that one cannot but take into account the effect of electromagnetic radiation on the development of daphnia, as this poses a threat to aquatic organisms.

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