The European Journal of Technical and Natural Sciences 2024, No 2
ISSN 2414-2352

PREMIER Publishing
ppublishing.org

Section 1. Electrical engineering

DOI:10.29013/EJTNS-24-2-3-9

ON THE ISSUE OF INCREASING THE EFFICIENCY OF USING SOLAR INSOLATION IN WATER-HEATING SOLAR COLLECTORS

Rustamov Nasim Tulegenovich [1], ***Kibishov Adylkhan Talgatovich*** [1], ***Mukhamejanov Nuridin Baktiyaruly*** [1], ***Seimanova Aida Saurbekkyzy*** [1]

[1] International Kazakh-Turkish University named after Khoja Ahmed Yasawi

Cite: *Rustamov, N. T., Kibishov, A. T., Mukhamejanov, N. B., Seimanova A. S. (2024). Thermal and Energy Characteristics of a Cogenerative Fractal Solar Collector. European Journal of Technical and Natural Sciences 2024, No 2.* https://doi.org/10.29013/EJTNS-24-2-3-9

Abstract

This paper considers an urgent issue related to increasing the efficiency of using solar insolation on water-heating solar collectors (WSC). Analyzing the structural changes of the WSC, in order to increase the effective use of solar insolation, a method is proposed without changing the design of the WSC to solve this issue. The essence of the proposed tracker is to use it to orient the WSC to the position of the Sun, using solar panels.

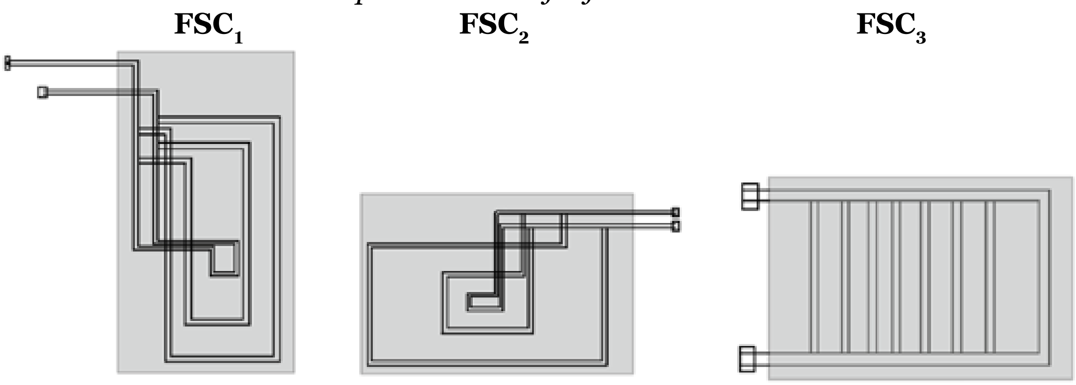
Keywords: *Orientation, position, Sun, solar collector, efficiency, solar insolation, automation, horizontal solar tracker*

Introduction

Today, flat water heating solar collectors (WSC) are widely used in practice. The main advantages of solar heat collectors are: high process efficiency even in subzero temperatures; ease of installation of the entire structure; anti-wind resistance of the collector; duration of operation. However, the efficiency of using solar insolation remains much to be desired. This is probably why many researchers and engineers working in this field, in order to increase the efficiency of using solar insolation, are trying to change the very design of the WSC and the materials used in this design (Avezova N. R., Avezov R. R., Rustamov N. T., Vakhidov A., Suleymanov Sh. I., 2013; Ermuratskij V. V., Postolatij V. M., Koptyuk E. P., 2009; Ermuratskij V. V., 2009; Avezova N. R., 2003). In this case, the cost of the thermal energy produced by WSC increases. It should be noted that the thermal and energy characteristics of these solar installations, in addition to its design and the use of various metal materials, also depend on the degree of how to use Solar insolation. This is an urgent task that needs to be solved today. Interestingly, due to the tilt of the Earth's axis, the Sun also moves 46° north and south during the year. Thus, the same set of WSC installed at the midpoint between two local extremes will see the Sun moving 23° in both directions. Given this situation, the researchers began using solar trackers at the WSC in order to increase the efficiency of using solar insolation in the production of thermal energy. The results were not encouraging (URL: https://dzen.ru/a/XmwFOKI43BdEorSK; URL: https://www.youtube.com/watch?v=7qq8g38jwd7; Pulungan A.B. et al. 2020; Brito M.C. et al. 2019). Due to the complexity of the tracker's design, the cost of the generated thermal energy did not really satisfy the consumer. Despite this, everyone knows that the aim of increasing the use of solar insolation in the WSC system is becoming in demand today.

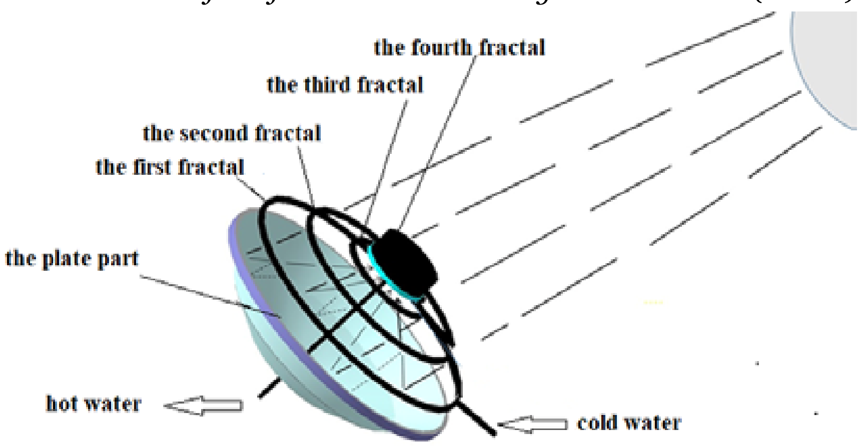
Interestingly, there are simpler methods to increase the efficiency of using solar insolation and the design of solar trackers on the WSC. In (Rustamov N.T., Kibishov A.T., Isroilov F.M., Ernazar K.E., 2023), a simple method for increasing the efficiency of using solar insolation at WSC is described. By changing the location of the absorbers on the aperture area of the WSC, it is possible to increase the efficiency of using solar insolation in a solar installation. The first option is shown in (Fig. 1).

Figure 1. *Different designs of the absorber arrangement on the aperture area of a flat solar collector*



The first method (Fig.1) (Rustamov N.T., Kibishov A.T., Isroilov F.M., Ernazar K.E., 2023): absorbers are positioned on the aperture area of flat solar water heating collectors according to the "golden section" principle. Fig.1 shows such an arrangement of absorbers (FSC_1 and FSC_2) FSC_3 is a classic arrangement of absorbers on the aperture area. The second method (fig. 2) Rustamov N., Kibishov A., Naci Genc, Shokhrukh Babakhan, Ernazar K. 2023). The absorbers are located on the aperture area of the parabolic concentrator according to the Fibonacci number principle. At the same time, by changing the fractal dimension of the absorbers, it is possible to further increase the efficiency of using solar insolation (Rustamov N.T., Mejrbekov A.T., Kibishov A.T., ot 30.06.2023). The third method. If we design a uniaxial horizontal solar tracker that causes the movement of the FWSC as shown in (Fig. 3), then it will also be possible to increase the use of solar insolation by a solar installation without changing the design of the WSC.

Figure 2. *General view of the fractal water heating solar collector (FWSC) design*

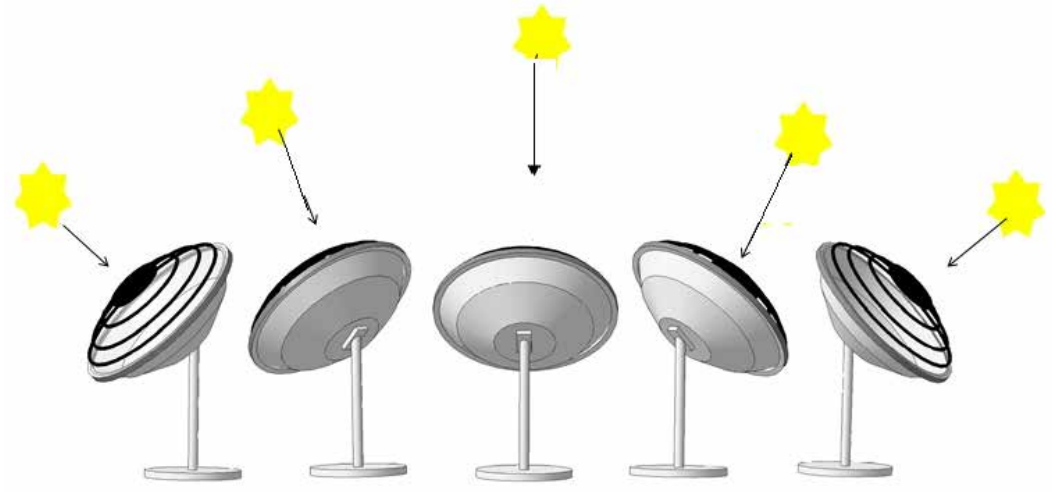


As you know, the Sun travels 360° from east to west per day, but from the point of view of any fixed location, the visible part is 180° maximum during the average period of half a day (more in summer, slightly less in spring and autumn and significantly less in winter). FWSC with a fixed orientation between the extreme points of dawn and sunset will move. approximately 75° in both directions and will lose more than 75% of energy in the morning and evening. The rotation of the FWSC to the east and west can help make up for these losses.

The aim of the work is to develop a horizontal solar tracker for a fractal water heating solar collector powered by a renewable energy source.

The solution method. By definition, a FWSC tracker is a system with rotary mechanisms that automatically deploys FWSC along the line of movement of the sun, as shown in Fig. 3. So more direct rays fall on their surface during the day, which increases the overall efficiency of using solar insolation by solar collectors. It is clear that the design of such a tracker should ensure a reduction in the cost of generated thermal energy. This is also one of the options for increasing the efficiency of using solar insolation, which does not require changing the design of the WSC.

Figure 3. *Options for the orientation of the fractal water heating solar collector to the movement of the Sun*



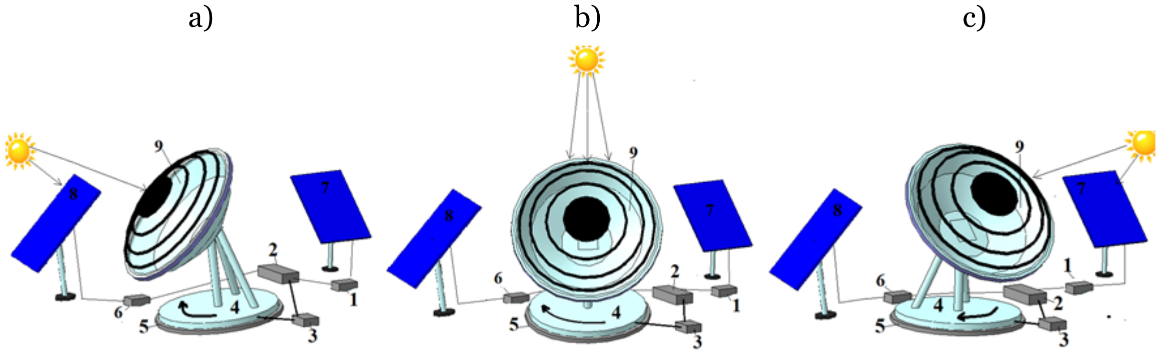
The tracker being developed should have the following functions: to be constantly pointed at the Sun, at best at a right angle. Tracking of the Sun, the FWSC should be carried out autonomously, i.e. without manual control. Remote control by connecting it to a horizontal tracker will also provide an opportunity to expand functions. In this case, the axis of rotation of the horizontal uniaxial tracker must be horizontal relative to the ground. To do this, the FWSC itself is attached to a rotating disk attached to a vertical axis.

To reduce the cost of the solar tracker, we will use solar photo panels to operate the engine. The rotating disc itself is put on a vertical axis attached to a non-moving disc. This type of horizontal solar tracker is most suitable for low latitude regions. The layout of the field for FWSC with horizontal uniaxial solar trackers is very flexible. The appropriate field can maximize the ratio of energy production to costs, and this depends on the local terrain and shading conditions, as well as on the time of day and the value of the energy produced. With this design of the horizontal solar tracker, reverse tracking is not required for the WSC. The FWSC are mounted on a rotating disk, and this disk will rotate around its axis to track the visible movement of the Sun during the day. Now the question arises how to rotate the disk where the FWSC is attached. To generate electricity for the rotating rotating disk engine, we will use a solar photo panel. Figure 4 shows such a horizontal solar tracker powered by renewable energy sources.

This system works as follows. In the morning, position c). When the sun's rays fall on the FWSC9 and on the solar panel 7, the FWSC9 begins to generate thermal energy and at the same time the solar photo panel 7 will generate electrical energy.

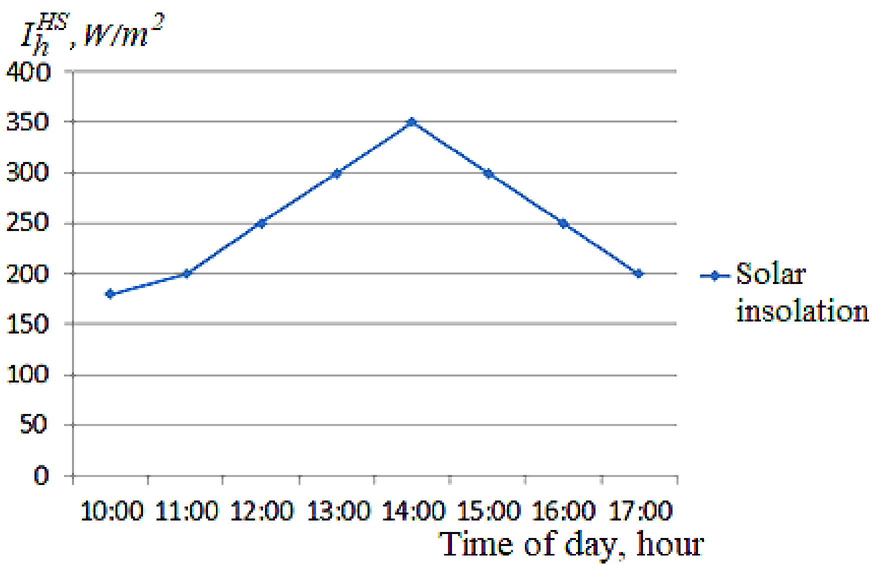
Here 1,6 is a controller, 2 is a reversible asynchronous motor, 3 is an electric drive, 4 is a rotating disk where the FWSC is attached, 5 is a support disk holding the rotating disk, 7,8 solar photo panels, FWSC9.

Figure 4. *Uniaxial horizontal solar tracker for FWSC operating on an alternative energy source*



The generated electrical energy is fed through the controller 1 to the reverse asynchronous motor 2. The reverse asynchronous motor using an electric drive 3 begins to rotate the rotating disk 4. At this time, the second solar photo panel 8 is in the shade, and does not generate electrical energy. Position b). Noon in this position, the first photo panel will be in the shade, the production of electrical energy is suspended. But the FWSC continues to generate thermal energy. The engine is not working. Position a). After lunch, the sun's rays fall on the second photo panel 8, it begins to generate electrical energy. The generated electrical energy is supplied to the engine 2 through the controller 6, the engine begins to rotate the disk 4 with the help of an electric drive 3. Thus, the FWSC9 will generate thermal energy during this period of movement. At this time, the first photo panel 7 remains in the shade, i.e. the sun's rays do not fall on this photo panel. When the movement of the Sun ends, the reversing engine returns the rotating disk 4 to its original position.

Figure 5. *Daily solar insolation for Turkestan (1.03.2023)*



These three designs were experimented with under the same external and internal conditions. At the same time, the aperture areas of the WSC and the size of the absorbers were the same. But the structures of the absorber arrangement were as shown in (Fig. 2 and 3).

Figure 5 shows the changes in solar insolation when the experiments were conducted.

From the graphs obtained as a result of the experiment, the efficiency of water-heating solar collectors shown in Figs.6 and 7, one can see the trend in the efficiency of using solar insolation depending on the location of absorbers on the aperture area of solar collectors.

Collectors where the absorbers are fractally arranged according to the principle of the "golden section" of FSC_1 and FSC_2 use solar insolation more effectively compared to where the absorbers are located on the aperture area parallel to the FSC_3. 6 and 7 shows that when the collector structure has a shape as shown in Figure 2, the efficiency of using solar insolation by a solar installation will be more efficient compared to previous VSCs. Since in this case, the solar installation uses solar insolation multiple times to generate thermal energy. This installation is patented (Rustamov N. T., Mejrbekov A. T., Kibishov A. T., ot 30.06.2023).

Figure 6. *Hourly efficiency of WSC with different absorber arrangements*

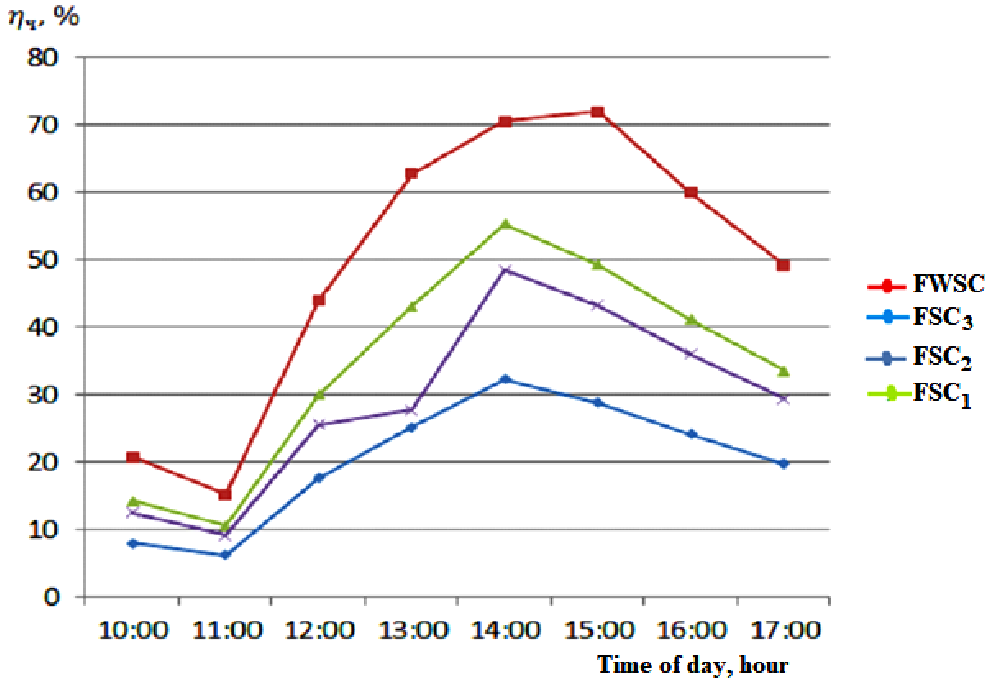
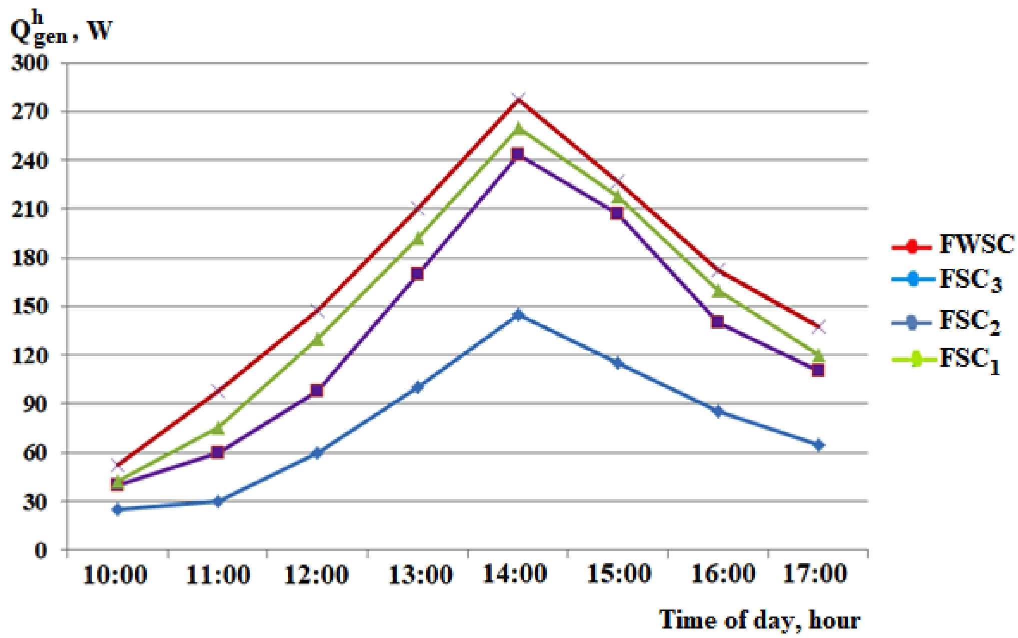


Figure 7. *Hourly WSC heat generation with different absorber arrangements*



The problem of increasing the use of solar insolation in water-heating solar collectors is strongly associated with a decrease in the cost of generated thermal energy. Analyzing the results of the experiment shown in Figures 6 and 7, we can say that when the WSC absorbers are located on the aperture area according to the "golden section" principle, if the WSC is flat and the absorbers are located on the aperture area of the parabolic concentrator fractally according to the Fibonacci number principle, then the efficiency of using solar insolation increases. This can be seen from the values of the hourly efficiency of water heating solar collectors and the hourly heat generation by these solar collectors.

Conclusions

Summarizing the work, we can say the following:

1. Absorbers and their locations in solar collectors are one of the main design elements in the heat supply of solar installations, on which both energy and economic indicators of solar heat supply systems depend.
2. In flat solar collectors, the absorbers are located in a planar projection. In such structures, the reflected from the aperture area is not used to generate thermal energy.
3. When the aperture area is a parabolic plane and the absorbers are located in this plane fractally according to the Fibonacci number principle, then solar insolation can be used in multiples
4. The concept proposed in the work methods for increasing the efficiency of using solar insolation by changing the location of absorbers in the aperture area of water heating collectors is objective.
5. The results of the experiments have shown that changing the location of absorbers on the aperture area can increase the efficiency of the WSC.
6. The proposed method of increasing the efficiency of the FWSC using a horizontal solar tracker is a fundamentally new approach not only to the design of a uniaxial horizontal solar tracker, but also to generate low-cost thermal thermal energy.

References

Avezova N. R., Avezov R. R., Rustamov N. T., Vakhidov A., Suleymanov Sh. I. Resource indexes of flat solar water-heating collectors in hot-water supply systems: 4. Specific collector thermal yield and efficiency. Journal Applied Solar Energy, 2013,– Vol. 49.– Issue 4.– P. 202–210.

Ermuratskij V.V., Postolatij V. M., Koptyuk E. P. Perspektivy primeneniya v Respublike Moldova solnechnyh nagrevatelej vody sanitarno-bytovogo naznacheniya. Problemy regional'noj energetiki. 2009.– № 2. URL: http://ieasm.webart.md/data/m71_2_107.doc

Ermuratskij V. V. Opredelenie koefficienta teplovyh poter' kollektora solnechnoj energii s absorberom iz polimernyh trub. Problemy regional'noj energetiki. 2009.– № 3. URL: http://ieasm.webart.md/data/m71_2_120.doc.

Avezova N. R. Issledovanie absorbcionnyh solnechnyh kollektorov s emkimi preemnikami polucilindricheskoj formy. Dissertaciya na soiskanie uchenoj stepeni k.t.n.– Tashkent, 2003.– 172 p.

URL: https://dzen.ru/a/XmwFOKI43BdEorSK

URL: https://www.youtube.com/watch?v=7qq8g38jwd7

Pulungan A. B. et al. Design and development of real time monitoring single axis solar tracker by using internet of things // International Journal. 2020.– T. 18.– № . 69.– P. 81–87.

Brito M. C. et al. Passive solar tracker based in the differential thermal expansion of vertical strips //Journal of Renewable and Sustainable Energy. 2019.– T. 11.– № 4.– P. 043701.

Rustamov N. T., Kibishov A. T., Isroilov F. M., Ernazar K. E. Koefficient poleznogo dejstviya vakuumirovannogo fraktal'nogo solnechnogo kollektor. European Journal of Technical and Natural Sciences – 2. 2023.–P. 46–53.

Nassim Rustamov, Adylkhan Kibishov, Naci Genc, Shokhrukh Babakhan, Ernazar Kamal. Thermal Conductivity of a Vacuum Fractal Solar Collector. International Journal of Renewable Energy Research N,– Vol. 13.– No. 2. June, 2023.– P. 613–618.

Rustamov N. T., Mejrbekov A. T., Kibishov A. T. Vakuumnyj fraktal'nyj solnechnyj kollektor. Patent RK na izobretenie № 36213 ot 30.06.2023.

submitted 15.03.2024;
accepted for publication 01.04.2024;
published 30.04.2024

Contact: babakhan.shokhrukh@ayu.edu.kz