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AGRICULTURAL SCIENCES

IMPORTANCE AND BENEFITS OF TECHNOLOGY IN AGRICULTURE

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Abstract

Rapid technological progress in agriculture has a tremendous impact on the agricultural sector. New satellite technologies in agriculture occupy a leading position and help more rationally manage resources, optimize field processing and increase their productivity. Higher yields and lower operating costs lead to increased income for agribusinesses. In addition, modern agricultural technologies to increase yields optimize the profitability of agricultural enterprises. Farmers successfully combine time-tested and new farming methods.

Keywords: agriculture, modern, technology, farmer, profitability

Introduction

The development of the modern agricultural sector occurs in several directions simultaneously, with the main focus being on the introduction of new technologies in agriculture. The use of best practices helps improve agricultural sustainability through smarter and more informed management decisions.

In addition, modern agricultural technologies to increase yields optimize the profitability of agricultural enterprises. Farmers successfully combine time-tested and new farming methods. For example, the sequence of crops in a crop rotation can be effectively planned using digital agriculture technologies to monitor field productivity based on satellite imagery.

New technologies in the agricultural sector (agritech) cover a wide range of industries and technical means aimed at increasing the productivity of agricultural enterprises. New agricultural technologies include a fleet of agricultural machinery, robotics, computers, satellites, drones, mobile devices and software. The use of big data analytics and artificial intelligence (AI) is another example of the adoption of innovative technologies in agriculture.

New technologies for the agricultural sector

New technologies for the agricultural sector are designed to simplify the work of agronomists and increase its efficiency. New, and sometimes completely innovative, agricultural technologies are improved and appear every year. As the agricultural business continues to modernize and grow, it is increasingly important for agricultural consultants, food processors and technologists to keep up with progress and understand advanced agricultural technologies.

Irrigation, application of fertilizers, pesticides and other agricultural inputs at large agricultural enterprises no longer occurs "by eye" or in equal quantities throughout the entire field. Thanks to new technologies

in agriculture, agronomists can apply only what is required on a particular site, and also carefully select the right treatment for each crop.

The introduction of new smart farming methods benefits everyone in the agri-food chain. The use of the latest technologies in agriculture to optimize and automate agricultural operations and field work can significantly save time and resources. Let's name the main advantages of using new agricultural Technologies[1]:

- Using irrigation water, fertilizers, pesticides and other resources in smaller quantities allows agricultural producers to reduce costs and retain more of their profits;
- reducing the volume of chemical runoff from fields and preventing pollution of water bodies mitigates the negative impact of farming on the environment and helps to increase the sustainability of agriculture;
- increasing productivity while reducing labor costs;
- simplification of interaction between participants in the agricultural process and coordination of their actions using mobile devices, new specialized applications or web resources;
- facilitating access to agricultural insurance and financial services, as well as market and technology data;
- minimizing losses due to the invasion of field pests, natural disasters and adverse weather conditions in the fields using permanent agricultural monitoring systems at reasonable prices;
- increasing the income of agricultural enterprises due to improving the quality of agricultural products and strengthening control over their quality;
- timely detection of nutrient deficiencies in plants and informing agricultural producers about the

type and quantity of necessary fertilizers and other agrochemicals for processing crops and increasing their productivity;

- The ability to predict potential problems in the field through new capabilities to visualize production patterns and patterns resulting from the application of new methods for analyzing current and historical field data.

Estimating overall crop yields helps farmers more accurately budget for the new crop growing season and better prepare for unexpected situations.

The new technology of precision or smart agriculture, also known as agriculture 3.0, has arisen from the need to monitor and more effectively manage all agricultural production resources used. The desire for precision agriculture and the introduction of appropriate technologies has given impetus to the development of new methods and tools for agriculture[2].

Era 3.0 became technically feasible through the use of a new global positioning system (GPS) satellite. In particular, the GPS system helps to find unwanted changes in a given crop growing area, which allows for more efficient use of available resources. The concept of sustainable agriculture and research in the field of automated field cultivation rely heavily on GPS technology and the new capabilities of this system.

New precision agriculture technologies that use GPS data help improve productivity and reduce wasted input costs such as seeds, fertilizers, pesticides and fuel. The GPS system not only provides location-based field information, but also simplifies the coordination of operations between individual pieces of agricultural equipment and the maintenance of records of completed field work on specialized platforms[3].

This new technology has a variety of applications in the agricultural sector:

- monitoring and management of field work;
- collection and analysis of data from the fields;
- precise sampling for soil analysis;
- crop mapping;
- navigation and control of new agricultural machinery;
- operation in conditions of poor visibility, for example during heavy rain or fog[4].

The transition from smart to connected farming clearly illustrates the rapid development of agriculture at the turn of the 20th and 21st centuries. Autonomous machines, sensor-equipped robots, augmented reality (AR), Internet of Things (IoT), drones and satellites are integral components of the new generation 4.0 technologies for agriculture.

A new approach to decision making in the agricultural sector is now based on data that is stored in the cloud and accessible through digital tools. With these insights, farmers and other agricultural industry stakeholders can make better decisions.

Agriculture 4.0 is born in the era of widespread automation and the use of digital technologies. The development of new agricultural technologies is becoming increasingly integrated and networked, making it possible to optimize all stages of the production process and improve monitoring, control and business management processes.

Robotic agricultural labor technology is a promising new workforce option for precision agriculture[3]. Autonomous operation of robotics will allow continuous field management, as well as increased productivity and efficiency of agriculture, since robots are able to collect information about their surroundings on their own site. Today, autonomous robots, controlled remotely using telemetry, are the most well-known and successfully used new agricultural equipment.

Digital Farming

Digital agricultural technologies are the next generation of new farming methods and tools aimed at maximizing yields and other agrotechnical indicators. These new technologies include 5G mobile communications, which are currently developing rapidly and will improve the coverage and accessibility of the latest technologies in agriculture around the world.

Compared to previous farming methods, new digital technologies in agriculture have the following advantages:

- efficiency of data collection: how much data can be collected over a given period of time or specified area;
- data accuracy: to what extent the obtained indicators correspond to the truth;
- Timeliness: How quickly captured data is converted into actionable information and made available to end users[5].

During the production process, farmers face a number of problems such as pest attacks and plant diseases. The weather factor in agriculture should also be taken into account: meteorological anomalies can cause serious damage to the crop. However, new digital technologies make it possible to minimize negative consequences. At the same time, with the help of new technologies, farmers can control those agricultural aspects that directly depend on them, and as a result, increase their profits. In particular, digital technologies in agriculture help to obtain an informed answer to the following questions:

- what types of crops to grow;
- how to optimally alternate crops in crop rotation;
- how often and in what volume to use water for precision irrigation;
- when to apply fertilizers and plant protection products, what and how much;
- which treatment is best suited for a given soil type.

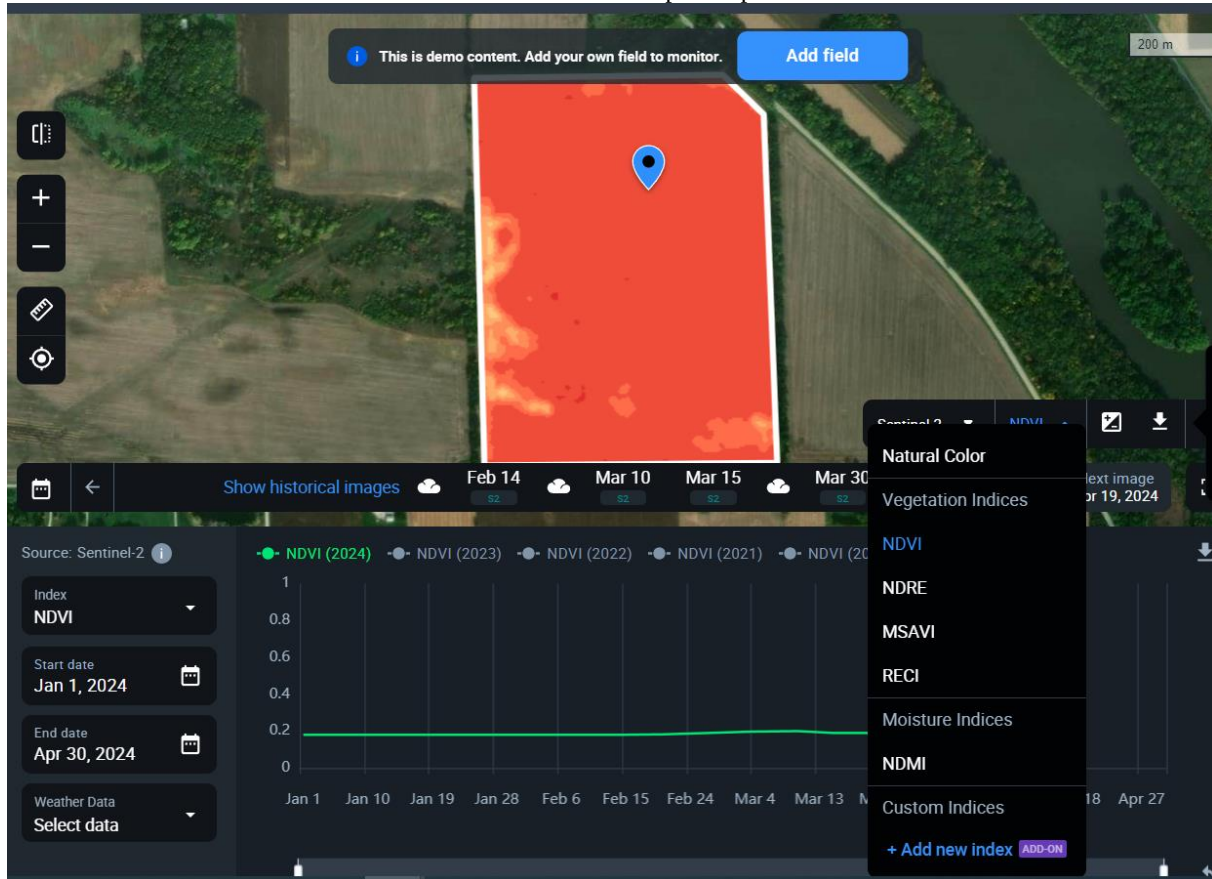
The competitive advantages of agricultural enterprises are ensured by the use of modern software, remote sensing technologies (especially high-resolution satellite images), proximal sensors, new means of communication and risk forecasting algorithms based on accurate data[5].

The use of big data in new agricultural technologies has led to intensified information flows, increased speed and accuracy of analysis and, as a result, increased the efficiency of decision-making processes and strategic planning.

Analysis of historical data about the field allows us to foresee the possible consequences of certain phenomena and factors, assess risks and develop an optimal action plan.

Information technology in agriculture is constantly improving, and specialized platforms can collect and store more and more data about fields. Relative humidity, nutrient content, soil pH and moisture, and historical weather data are just a few of the indicators that can be extracted using satellite technology in agriculture.

In particular, the EOSDA Crop Monitoring platform contains extensive information on soil moisture values at the surface and in the root zone, vegetation productivity, crop types, field height, weather conditions (historical precipitation and temperature). On this platform it is convenient to plan and keep records of completed field work (watering, sowing, harvesting), analyze the size of the field and harvests of previous seasons. Based on data in a simple and accessible format, platform users can detect risks, as well as plan crops and predict future harvests.



The functionality of EOSDA Crop Monitoring finds practical application both in individual farm enterprises and in agricultural cooperatives.

Geographic information systems (GIS) are an emerging and essential tool for storing, analyzing, and visualizing spatial data for precision agriculture needs. One of the most important aspects of the application of GIS technology in agriculture is the collection of information about crops, soil, climate and topography of a region using satellites and drones. In addition, it is thanks to new GIS technologies used in agriculture that the combined use of GPS applications and smart farming tools for optimal distribution of fertilizers and pesticides becomes possible[3].

Using new GIS technologies in the EOSDA Crop Monitoring platform, users can create field productivity maps based on a baseline NDVI index over several years. Using these yield maps, you can accurately determine the most productive areas of the field, as well as low-yield areas that would be advisable to fertilize or increase field productivity by other methods.

Applying the correct amount of fertilizer to the soil can be difficult, but yield maps can help with the

challenge. Thus, new technologies in agriculture not only help reduce financial costs for the purchase of fertilizers, but also prevent soil and groundwater pollution due to inappropriate use of chemicals.

Innovative Technologies in Agriculture

Technologies for the agricultural sector have come a long way in development and are used not only to perform the main stages of the agricultural process: sowing, growing and harvesting.

The agricultural sector has seen a number of major advances in recent years, from improved seed viability to improved planning and processing of agricultural products. New agricultural technologies also help optimize planning for the sale of agricultural products and improve logistics solutions for their delivery to the end consumer.

Rapid progress is also being made in the development and application of agricultural software and new technologies that facilitate not only field work but also the management of various components of the food supply chain. If previously it was necessary to personally go to the field for inspection, now this can be done

remotely. Modern technologies for processing Earth remote sensing data serve this purpose perfectly.

Although modern agriculture benefits greatly from the development of new technologies in terms of increasing efficiency, reducing costs and increasing yields, there is another side to the coin associated with large-scale extensive agriculture. The most significant disadvantage of new farming technologies is the detrimental impact on the environment. The harmful effects of new agricultural technologies on ecosystems are due to the following factors:

- contamination of soil and water resources as a result of large-scale use of pesticides;
- reduction in biodiversity due to the extirpation of plant species characteristic of the region as a result of crop cultivation;
- greenhouse gas emissions resulting from deforestation for the purpose of plowing agricultural land and the excessive use of new agricultural machinery in the future[2].

The harmful effects of new technologies on the agricultural sector are not limited to environmental issues. The introduction of new technologies in agriculture also causes certain difficulties for agronomists and other workers in the fields, namely:

- farmers who do not have the necessary education and practical experience cannot effectively use new technology and software, and therefore are not unable to benefit from the use of modern agricultural technologies;
- the cost of maintaining new equipment is high;
- Application of chemical fertilizers and pesticides can harm the health of farmers and other workers who work in the fields[6].

It is clear that we cannot completely abandon new agricultural technologies as they help meet the food needs of a growing global population. However, the negative consequences of new agricultural technologies can be mitigated by using and improving precision farming methods that do not harm the environment.

Because new agricultural technologies can reduce or even minimize the negative impacts of traditional farming methods, they help solve a wide range of environmental problems. In this way, intensive farming enthusiasts can get two birds with one stone: increase their competitiveness and contribute to the long-term well-being of our planet's population.

Conclusion

In the era of information discoveries, new technologies are increasingly being used in the agricultural sector. Agribusinesses are using modern technology to optimize field management, and this is just one of many examples of how innovation is driving progress in agriculture.

The volume of fertilizers, pesticides and other agricultural inputs used can be reduced with the help of new agricultural technologies and appropriate software. Another advantage of innovation is that new farming technologies help reduce emissions of carbon dioxide and other harmful substances that pollute the environment. This achievement was made possible by streamlining the agricultural production process and eliminating unnecessary steps. The yield of the resulting crops can be further increased through precise application of fertilizers.

In addition, new methods of mechanization of agricultural processes increase the productivity and efficiency of agribusiness at all stages of agricultural production, in particular during sowing, harvesting and marketing of agricultural products.

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STUDY OF SUNFLOWER HYBRIDS OF THE FIRST (F₁) AND SECOND (F₂) GENERATION OF FOREIGN ORIGIN IN THE CONDITIONS OF ABSHERON**Gadimova A.,***senior researcher, Research Institute of Crop Husbandry of Azerbaijan Republic***Yusifova G.,***scientific worker, Research Institute of Crop Husbandry of Azerbaijan Republic***Hajiyeva L.***scientific researcher, Research Institute of Crop Husbandry of Azerbaijan Republic***ИЗУЧЕНИЕ ГИБРИДОВ ПОДСОЛНЕЧНИКА ПЕРВОГО (F₁) И ВТОРОГО (F₂) ПОКОЛЕНИЯ ЗАРУБЕЖНОГО ПРОИСХОЖДЕНИЯ В УСЛОВИЯХ АПШЕРОНА****Кадимова А.Б.***старший научный сотрудник, Азербайджанский Научно-Исследовательский Институт Земледелия***Юсифова Г.М.***научный сотрудник, Азербайджанский Научно-Исследовательский Институт Земледелия***Гаджиева Л.Б.***научный сотрудник, Азербайджанский Научно-Исследовательский Институт Земледелия*<https://doi.org/10.5281/zenodo.11387056>**Abstract**

The article presents the results of studying a number of economically important traits of 21 combinations of the first (F₁) and 22 combinations of the second (F₂) sunflower hybrids. The research was carried out in 2023 at the Absheron subsidiary experimental farm of the Research Institute of Crop Husbandry under Irrigated Conditions. During the year of research, hybrid combinations of first and second generation sunflowers of Belarusian and Turkish origin were studied.

Based on the height and diameter of the basket, the studied plants belonged to oilseed samples.

Аннотация

В статье представлены результаты изучения ряда хозяйственно важных признаков 21 комбинации первого (F₁) и 22 комбинаций второго (F₂) гибридов подсолнечника. Исследования проводились в 2023 году на Апшеронском подсобном опытном хозяйстве НИИ Земледелия в условиях орошения. В год исследований были изучены гибридные комбинации подсолнечника первого и второго поколения Белорусского и Турецкого происхождения. Посев проводился 12 апреля по схеме 0,7×0,25. В ходе исследований были изучены период вегетации гибридных растений, высота растений, диаметр корзинки.

Наблюдалась разница в периоде вегетации 43 изученных гибридных комбинаций подсолнечника первого и второго поколения. Так, 8 комбинаций относились к среднераннеспелой группе, а 35 комбинаций относились к среднепоздней группе

Высота гибридов первого поколения (F₁) находится в пределах 90-128 см; а высота гибридов второго поколения (F₂) варьировала в пределах 88-130 см. Это указывает на принадлежность изученных гибридов к масличным образцам. У изученных гибридных образцов диаметр корзинки варьировал в пределах 15-20 см.

Таким образом, по высоте и диаметру корзинки исследованные растения относились к масличным образцам.

Keywords: sunflower, diversity, hybrid, form, vegetation**Ключевые слова:** подсолнечник, разнообразие, гибрид, форма, вегетация

Подсолнечник в основном выращивают в России, Украине, Аргентине, Китае, Казахстане, Турции, США. По статистическим данным, посевная площадь подсолнечника в мире достигает 26 миллионов 533 тысяч 596 га. Из него было произведено 45 миллионов тонн продукции. Начиная, с 2015 года выращивание подсолнечника в Азербайджане осуществлялось на больших площадях, так что в 2019 году посевная площадь подсолнечника в стране составила 16551 га, в результате урожайность составила 21ц/га. [3].

Подсолнечник относится к группе масличных растений. В мировом опыте при производстве растительных масел используется более 20 растений. Среди растительных масел, выпускаемых для пищевого масла, подсолнечное занимает второе место [9].

Сегодня работа над повышением урожайности подсолнечника ведётся очень активно. Работники отделов селекции, земледелия, растениеводства и других областей сельского хозяйства каждый день проводят исследования и опыты для выявления и повышения урожайности подсолнечника. И хотя

подсолнечник является не самой отзывчивой культурой как на внесение удобрений, так и на обработки почвы и повышение количества осадков, учёным удалось повысить его урожайность на сегодняшний день в лучших хозяйствах до 40 ц/га с масличностью до 55% [7].

Почвенно-климатические условия Азербайджанской Республики позволяют широко выращивать различные растения. В настоящее время важным вопросом в нашей республике является обогащение генетических ресурсов новыми генными источниками и их эффективное использование в обеспечении продовольственной безопасности населения. Культурные и дикорастущие виды Астровых широко распространены в разных регионах республики. Среди культурных видов большое хозяйственное значение имеет подсолнечник.

Приоритетным направлением при решении проблемы стабилизации и повышения производства подсолнечника и получения высоких, устойчивых урожаев семян высокого качества является дальнейшее совершенствование элементов технологий возделывания данной культуры применительно к конкретным почвенно-климатическим условиям, использование достижений селекции [4].

Основной целью семеноводства подсолнечника является получение физиологически зрелых, здоровых, генетически и физически чистых семян, которые обладают высокой энергией прорастания и всхожестью [2].

Оценка урожайных свойств семенного материала сортов и гибридов подсолнечника, выращенных в различных почвенно-климатических зонах показала, что их потомство не отличается по основным

хозяйственно полезным признакам как вегетационный период, высота растений, урожайность, масличность, массы 1000 семян и т.д. [5; 6]. Из этого следует практически важный вывод о том, что качественный семенной материал сортов и гибридов подсолнечника при наличии необходимой материально-технической базы семеноводства и соблюдения научно обоснованной технологии выращивания можно получить в различных почвенно-климатических зонах страны [1].

Материал и методика. Исследования проводились в 2023 году на Апшеронском подсобном опытном хозяйстве НИИ Земледелия в условиях орошения. В год исследований были изучены гибридные комбинации подсолнечника первого и второго поколения Белорусского и Турецкого происхождения. Посев проводился 12 апреля по схеме 0,7×0,25.

В месяцы вегетационного периода (апрель-август) среднемесячная температура была близка к климатической норме и несколько выше для района исследований. Среднемесячная температура составила 11-13 °С в апреле, 18-20 °С в мае, 24-26 °С в июне, 26-28 °С в июле и августе, что близко к климатической норме и немного высокий для исследуемого региона.

Выводы и обсуждения. В ходе исследований были изучены период вегетации гибридных растений, высота растений, диаметр корзинки.

Наблюдалась разница в периоде вегетации 43 изученных гибридных комбинаций подсолнечника первого и второго поколения. Так, 8 комбинаций относились к среднераннеспелой группе, а 35 комбинаций относились к среднепоздней группе (Диаграмма 1).

Диаграмма 1

Продолжительность вегетационного периода у гибридов подсолнечника первого (F₁) и второго (F₂) поколений.



Из 21 гибрида первого поколения (F₁) 18 комбинаций относились к среднепозднеспелым образцам с вегетационным периодом 111-112 дней; а остальные 3 комбинации относились к среднераннеспелым образцам с вегетационным периодом 109 дней.

Из 22 изученных генотипов гибридов второго поколения (F₂) 17 комбинаций относились к среднепозднеспелой группе с вегетационным периодом

111-112 дней; а остальные 5 комбинаций относились к среднераннеспелым образцам с вегетационным периодом 106-110 дней.

Высота гибридов первого поколения (F₁) находится в пределах 90-128 см; а высота гибридов второго поколения (F₂) варьировала в пределах 88-130 см. Это указывает на принадлежность изученных гибридов к масличным образцам.

По данным литературы диаметр корзинки у масличных образцов составляет 10-20 см [8]. У изученных гибридных образцов диаметр корзинки варьировал в пределах 15-20 см.

Заключение. Таким образом, по высоте и диаметру корзинки исследованные растения относились к масличным образцам.

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BIOLOGICAL SCIENCES

ON THE RHIZOSPHERE OF FIELD CROPS AND FACTORS INFLUENCING THE DYNAMICS OF ITS MICROBIOTA

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О РИЗОСФЕРЕ ПОЛЕВЫХ КУЛЬТУР И ФАКТОРАХ, ВЛИЯЮЩИХ НА ДИНАМИКУ ЕЕ МИКРОБИОТЫ

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Abstract

There is presented a review of literary sources, which disclosed an importance of rhizosphere being a certain biological buffer regulating interrelations between higher plants and soil and inhabiting soil microorganisms. The main factors influencing indicators of activity of rhizosphere microbiota possessing a complex of useful qualities for plants (converting of nutrient into accessible forms, decomposition of organic materials, increase of resistance to abiotic factors, stimulating a growth, antagonism to phytopathogens, etc.) are considered. The violations of interrelations between plants and their associative microorganisms caused by different factors, including the regulating by human ones – such as cultivation technologies, are able to decrease yield potential of agricultural crops including sunflower. The analytical review certifies the prospects to conduct researches allows determining an impact of agrotechnical methods (sowing dates, seed sowing rates, fertilizer, and chemical and biological plant protection) on changes in qualitative and quantitative composition of microbiota in sunflower rhizosphere and to determine their influence on yield and quality of products.

Аннотация

Приведен обзор литературных источников, показывающий значимость ризосферы, являющейся определённым биологическим буфером, регулирующим взаимоотношения высших растений с почвой и населяющими её микроорганизмами. Рассмотрены основные факторы, влияющие на показатели активности ризосферной микробиоты, обладающей комплексом полезных для растений свойств (перевод в доступные формы элементов питания, разложение органических материалов, повышение устойчивости к абиотическим факторам, стимуляция роста, антагонизм к фитопатогенам и т.д.). Нарушения во взаимоотношениях между растениями и их ассоциативными микроорганизмами, вызванные различными факторами, в том числе и регулируемые человеком – технологиями возделывания, могут значительно снизить потенциал урожайности сельскохозяйственных культур, в числе которых находится и подсолнечник. Проведенный аналитический обзор свидетельствует о перспективности проведения исследований, позволяющих установить влияние агротехнических приёмов (срок посева, норма высева семян, удобрение, химическая и биологическая защита растений) на изменение качественного и количественного состава микробиоты в ризосфере подсолнечника, а также определить их влияние на урожай и качество получаемой продукции.

Keywords: soil microflora, rhizosphere, microbiota, associative symbiosis, sunflower, cultivation technology, soil

Ключевые слова: почвенная микрофлора, ризосфера, микробиота, ассоциативный симбиоз, подсолнечник, технология возделывания, почва

Почва – это не физическая или химическая, а прежде всего биологическая и биохимическая система, одним из главных компонентов которой является почвенная микрофлора. Микроорганизмам принадлежит ведущая роль в разложении растительных остатков, синтезе и деструкции гумуса, формировании фитосанитарного состояния почвы, накоплению в ней биологически активных веществ, фиксации атмосферного азота и т.д. Кроме того, почвенные микроорганизмы играют важную роль в формировании плодородия почвы и питания расте-

ний [1; 2]. Высшие растения, являясь основным источником питательных веществ для преобладающего числа микроорганизмов, населяющих почву, оказывают существенное влияние на микробные ценозы. Вокруг корней вегетирующих растений образуется особая зона, в которой создаются более благоприятные условия существования как для растений, так и для микроорганизмов. Численность микробов в прикорневой зоне более значительна, чем в остальной массе почвы. Это связано прежде всего с выделениями из корней (экзоосмосом) органических веществ, синтезированных растениями.

Кроме того, в зоне обильного скопления и развития корней улучшаются физические свойства почвы: почвенные частицы оказываются более структурированными, благодаря чему улучшается процесс дыхания корней и микроорганизмов, поддерживается стабильная температура, лучше сохраняется влага благодаря способности корневых систем растений активно изменять влажность окружающей их среды. Также корни увеличивают кислотность прилегающих к ним микрослоев почвы (в пределах нескольких миллиметров) за счёт выделения углекислоты и H^+ ионов. Он и предложил термин «ризосфера». Ризосфера – это узкий слой почвы, прилегающий к корням растения и попадающий под непосредственное действие корневых выделений и почвенных микроорганизмов, толщиной около 2–5 мм в диаметре. Границы ризосферы зависят от вида растения, типа почвы, влажности и ряда других факторов. Для микробной популяции – это доли миллиметра, для влаги и подвижных элементов питания – до десяти миллиметров, для газообразных соединений – десятки миллиметров. Без глубокого понимания происходящих в почвах ризосферы процессов невозможно создавать системы устойчивого земледелия и решать многие экологические проблемы. В современном понимании ризосфера – это центральный компонент экосистем и биогеохимических циклов химических элементов, место взаимодействия между почвой, корнями, микроорганизмами и почвенной фауной. Взаимоотношение растений с ризосферной микрофлорой носит характер раздельного симбиотрофизма, то есть они обоюдно полезны и растениям, и микроорганизмам. При этом наиболее интенсивно осуществляется конкуренция между представителями биоты за элементы питания. Ризосферная почва существенно отличается от вмещающей (неризосферной) почвы по большинству показателей, характеризующих как состав твердой фазы и раствора, так и функционирование отдельных компонентов почвенной системы: кислотности, влажности, температуры, ферментативной активности, скорости разложения клетчатки, биологической токсичности и т. д. В ризосфере более энергично, чем в свободной почве, протекают многие химические и биохимические процессы за счёт корневых выделений, а также повышенной концентрации продуктов метаболизма микроорганизмов и «пограничных» клеток. Наличие этих разнообразных веществ приводит к существенным изменениям в циклах химических элементов, в том числе и элементов питания, к интенсификации круговорота углерода и процессов выветривания минералов и разложения органического вещества. Корневые выделения (корневые экссудаты) представляют собой низкомолекулярные органические вещества, являющиеся продуктами фотосинтеза и метаболизма растений.

Наиболее важные специфические особенности почв в ризосфере связаны с непрерывным поступлением в почву экссудатов корней, продуктов метаболизма микроорганизмов. Почва ризосферы очень разнообразна. В состав ризосферной микробиоты

входят различные микроорганизмы: бактерии, актиномицеты, грибы, водоросли, дрожжи, простейшие, фаги и другие живые существа. Преобладающими в ризосфере растений независимо от условий их роста и возраста являются бактерии, второе место занимают микобактерии, в несравненно меньшем количестве присутствуют актиномицеты, грибы, спороносные бактерии и др. Неспороносные бактерии составляют основную, самую обширную и разнообразную группу ризосферной микробиоты, их количество может достигать 99,5 % от численности микробного населения ризосферы. В состав этой группы входят представители различных семейств, родов и видов: азотобактер, клубеньковые бактерии, тиобактерии, фотобактерии, азотомонас, сульфомонас, нитрификаторы, денитрификаторы и пр. В одном грамме почвы содержатся миллиарды аммонификаторов и денитрификаторов, а нитрификаторов и целлюлозолитических бактерий сравнительно мало. На втором месте по количеству стоят микобактерии, число которых достигает сотен тысяч и миллионов. Доли процента составляют в ризосфере спороносные бактерии, особенно мало их в период активной вегетации растений, так как данная группа бактерий развивается преимущественно на мёртвых, разрушающихся корнях. Бактерии образуют с корневой системой растений прочные ассоциации и формируют специфические ризосферные бактериальные сообщества. Такие взаимоотношения характеризуются терминами «ассоциативные бактерии», «ассоциативные взаимоотношения», «ассоциативный симбиоз».

Растения для содержания ризосферного бактериального сообщества теряют 30–50 % продуктов фотосинтеза в виде корневых экссудатов и ризодепозитов, однако это компенсируется тем, что ризобактерии осуществляют: контроль поступления в корень минеральных элементов из почвы; связывание газообразного азота атмосферы и улучшение за счёт него азотного питания растений; синтез фитогормонов; ингибирование роста растений различными метаболитами; потребление и разрушение корневых выделений вегетирующих растений, что положительно влияет на процесс корневого питания; подавление активности неблагоприятной для растений микробиоты; стимулирование эндосимбиоза растений и микроорганизмов; разложение целлюлозы; синтез витаминов, полисахаридов, гетероауксинов, и тем самым оказывают определенное влияние на развитие растительного организма. Функция азотфиксации ранее приписывалась лишь ограниченному кругу свободноживущих бактерий – *Azotobacter*, *Clostridium*, *Azospirillum*, *Beijerinckia*, *Derxia*. В настоящее время считается, что к фиксации азота из атмосферы способны 80–90 % всех известных бактерий, это представители родов: *Azospirillum*, *Herbaspirillum*, *Acetobacter*, *Agrobacterium*, *Azotobacter*, *Pseudomonas*, *Enterobacter*, *Klebsiella*, *Burkholderia*, *Flavobacterium*, *Campylobacter* [3]. Такой тип азотфиксации получил название ассоциативной, в отличие от симбиотической, характерной для бактерий,

обитающих в клубеньках бобовых растений. Данный процесс протекает практически во всех типах почв в ризосфере растений самых разных мест обитания. Особенностью ассоциативных бактерий является то, что они не образуют на корнях растений каких-либо специализированных структур типа клубеньков. Масштабы ассоциативной азотфиксации в зоне умеренного климата достигают 50–150 кг/га молекулярного азота за вегетационный период, в тропических широтах – от 200 до 600 кг/га в год, что говорит о большом экологическом значении данного способа пополнения фонда доступного растениям азота в большинстве природных экосистем.

Доказано, что в почве при наличии растений уровень азотфиксации значительно выше, чем в их отсутствии. Фосфор в почве присутствует в виде органических (отложения растительного, животного и микробного происхождения) и неорганических (минеральных) соединений, но только около 5 % его доступно растениям, так как большая часть находится в форме фитина (соль инозитфосфорной кислоты), нуклеиновых кислот, фосфолипидов. В улучшении фосфорного питания растений значительную роль играют ризосферные бактерии, которые за счёт синтезируемых ими ферментов – фитазы, нуклеазы, фосфатазы, фосфолипазы, осуществляют минерализацию этих соединений с образованием доступных форм фосфора [3]. Под влиянием микрофлоры в ризосфере отмечается увеличение растворимости соединений железа и марганца и других металлов, так как они находятся в соединениях с органическими веществами, образуемыми микробами, следовательно, лучше усваиваются растениями. Что подтверждено Вайнштейном и соавторами в лабораторном опыте с подсолнечником, где в отсутствии микробов и их метаболитов данные элементы не усваивались растениями. Эти наблюдения показывают, что растения усваивают железо не в виде минеральных соединений, а в форме органоминеральных веществ, образующихся под влиянием микроорганизмов [2]. Актиномицеты составляют менее 1 % от общего числа микроорганизмов ризосферы и встречаются преимущественно к концу вегетации растений. Виды актиномицетов, обитающих в ризосфере и в почве, не отличаются по видовому составу и физиологии.

Наряду с бактериями и актиномицетами грибы – постоянные обитатели прикорневой зоны растений, представляют собой либо типичных экстротрофов, использующих корневые выделения растений, либо патогенных и потенциально патогенных

организмов. Однако их видовой состав в ризосфере значительно более однообразный, чем вне ризосферы в первую очередь за счёт того, что подвижные бактерии в насыщенной влагой среде передвигаются и размножаются намного быстрее. Количество гумуса также влияет на численность грибов. В почвах, бедных органикой, увеличение численности микрофлоры в ризосфере более значительно, чем в сильно гумусированных, так как в первых более заметен рост органического вещества за счёт корневых выделений. Физиологически активные вещества, выделяемые корнями растений, оказывают как прямое стимулирующее действие на грибные ценозы, так и опосредованное за счёт стимуляции роста в ризосфере микробов-антагонистов к определённым видам грибов, тогда как при угнетении роста антагонистов могут усиленно размножаться многие грибы, в том числе фитопатогенные и некоторые симбионты [1]. Фитопатогенные грибы рассматриваются как почвенные, хотя многие из них (преимущественно специализированные) находятся в почве в состоянии покоя и прорастают только тогда, когда стимулируются экссудатами корней. Микробиота ризосферы является определённым биологическим барьером, влияющим на взаимоотношения высших растений и патогенов, играя значительную роль в иммунитете растений. Растения также могут способствовать развитию и накоплению в почве микробов-антагонистов к фитопатогенным бактериям, грибам, актиномицетам и даже вирусам, а также к азотобактеру, клубеньковым бактериям, микоризным грибам. Однако при неблагоприятных условиях для роста растений в их ризосфере развиваются и накапливаются фитопатогенные микроорганизмы.

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RESULTS OF A STUDY OF THE SPECIES COMPOSITION AND NUMBER OF RODENTS IN THE MOYYNKUM DESERT PLAGUE FOCUS IN 2021

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РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ВИДОВОГО СОСТАВА И ЧИСЛЕННОСТИ ГРЫЗУНОВ В (МОЙЫНКУМСКОМ ПУСТЫННОМ ОЧАГЕ ЧУМЫ В 2021 ГОДУ)

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Abstract

In the spring of 2021, on the territory of the Southern valley landscape epizootological region of the Moynkum natural plague focus, located in the west of the Zhambyl region of Kazakhstan, during an epizootological survey, censuses were taken of the number of rodents - the main and secondary carriers of the pathogen, as well as their natural enemies - predators. During the survey period, a low number of the main carrier of the summa pathogen, the great gerbil, was noted (249 individuals per 1 km², with colony habitability of 37.8%, the density of colonies per 1 km² was 152, and the average number of individuals per 1 colony was 4.4). The number of minor carriers (midday, red-tailed and combed gerbils) is extremely low and was zero at the time of the study. 12 individuals of the small jerboa were encountered along the 10 km route, and 20 animals were encountered of the yellow gopher. Of the terrestrial predators - natural enemies of rodents, 3 foxes and 1 wolf were encountered, and of the

feathered predators - the Buzzard (an average of 2-4 birds were observed per 10 km of the auto route). Meadow harrier, kestrel and brown owl were rarely seen.

Аннотация

Весной 2021 года на территории Южного придолинного ландшафтно эпизоотологического района Мойынкумского природного очага чумы, расположенного на западе Жамбылской области Казахстана в ходе эпизоотологического обследования были проведены учеты численности грызунов - основных и второстепенных носителей возбудителя, а также их естественных врагов - хищников. В период обследования была отмечена низкая численность основного носителя возбудителя сумы - большой песчанки (249 особей на 1 км², при обитаемости колоний - 37,8 %, плотность колоний на 1 км² - 152, а среднее число особей на 1 колонию - 4,4). Численность второстепенных носителей (полуденная, краснохвостая и гребенчиковый песчанки) крайне низкая и на момент исследования была равна нулю. Малого тушканчика на 10 км маршрута было встречено 12 особей, а желтого суслика было встречено 20 зверьков. Из наземных хищников - естественных врагов грызунов были встречены 3 лисы, 1 волк, а из пернатых хищников - канюк-курганник (на 10 км авто маршрута отмечено в среднем 2-4 птицы). Редко встречались лунь луговой, пустельга и сыч домовый.

Keywords: rodents, natural focus of plague, landscape-epidemiological region, carriers of the plague pathogen, greater gerbil, lesser gerbil.

Ключевые слова: грызуны, природный очаг чумы, ландшафтно-эпизоотологический район, носители возбудителя чумы, большая песчанка, малые песчанки.

Введение. Грызуны, особенно крысы и их блохи, исторически были связаны с передачей бубонной чумы, также известной как «Черная смерть». Бактерия *Yersinia pestis*, вызывающая чуму, может переноситься грызунами, особенно некоторыми видами крыс, такими как черная крыса (*Rattus rattus*) и коричневая крыса (*Rattus norvegicus*).

Чума в первую очередь передается человеку через укусы зараженных блох, обитающих на этих грызунах. Когда зараженная блоха питается кровью человека, она может передавать бактерии, что приводит к заражению. Кроме того, контакт с инфицированными грызунами или контакт с их биологическими жидкостями также может привести к передаче заболевания.

Хотя современные санитарные методы и меры борьбы с вредителями значительно снизили риск передачи чумы от грызунов, в некоторых странах мира это остается проблемой, особенно в регионах, где гигиенические стандарты низкие или где популяции грызунов многочисленны.

В Казахстане почти всю южную половину республики (39% площади) занимают наиболее активные природные очаги чумы, которые подразделяются на Ландшафтно-эпизоотологические районы (ЛЭР) [1]. Южный придолинный ЛЭР расположен на западе Жамбылской области и относится к Мойынкумскому пустынному очагу, который в свою очередь входит в состав Центральноазиатского пустынного очага чумы.

Впервые эпизоотия чумы среди диких грызунов на данной территории зарегистрирована в 1964 году, и протекала она с различной интенсивностью по 1966 год включительно [1].

Осенью 1988 года, после 22-х летнего перерыва вновь была выявлена эпизоотия чумы на центральном и западном участках Южного Придолинного района и длилась она до весны 1990 года. За этот период эпизоотия чумы протекала с различной интенсивностью, но преимущественно носила локальный характер [2].

С осени 1990 года и по осень 1994 г., несмотря на обследование территории, эпизоотии чумы не зарегистрирована. С 1995 - 1999г.г. отмечалась депрессия численности основного носителя чумы и его блох, в это были проведены только рекогносцировочные обследования данной территории [3].

Весной 2000 года, после девятилетнего меж-эпизоотического периода (1990-1999г.г.), была выявлена эпизоотия чумы в окр. «фермы №4», ур. «Нарбай», ур. «Шомбы» и ур. «Майнеке». Эпизоотия чумы на всех участках характеризовалась как локальная на общей площади - 400 км². Осенью 2000 года эпизоотия чумы была выявлена в ур. «Сужал», ур. «Шитас», окр. п. Болтирик, ур. «Кожакудык», которая на всех участках характеризовалась как локальная, малоинтенсивная на общей площади 400 км² [4].

Осенью 2001 года эпизоотия чумы была выявлена в окр. п. Болтирик, которая характеризовалась как локальная, малоинтенсивная на общей площади 100 км² [5].

Весной 2002 года эпизоотия чумы была выявлена в ур. «Аккудук» и характеризовалась как локальная, малоинтенсивная и протекала на общей площади 100 км² [6].

Весной 2003 года была выявлена эпизоотия чумы в окр. п. Кошек Батыра, окр. Аманкельдинского газового месторождения. Эпизоотия на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 200 км². Осенью 2003 года была выявлена эпизоотия чумы в окр. п. Кошек Батыра и носила локальный, малоинтенсивный характер и протекала на общей площади 100 км² [7].

Осенью 2004г. была выявлена эпизоотия чумы в ур. «Коныр» и ур. «Нарбай». Эпизоотия протекала на общей площади 200 км² и характеризовалась как локальная, малоинтенсивная [8].

Весной 2007 года на центральном участке ЛЭР в ур. «Аккудук» обнаружена серопозитивная краснохвостая песчанка, а в ур. «Жуантобе» - серопозитивная полуденная песчанка [9].

Осенью 2008 г на центральном участке ЛЭР, в ур. «Жуантобе», у двух полуденных песчанок и одной гребенщиковой песчанки выявлены положительные серологические реакции. На западном участке ЛЭР, в п. «Ушарал», у двух больших песчанок выявлены положительные серологические реакции [10].

Весной 2009 г. эпизоотия чумы выявлена в урочищах «Аккудык» и «Коныр». Эпизоотия чумы на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 200 км². Осенью 2009 г. эпизоотия чумы выявлена в окр. «Амангелды газ» и на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 100 км² [11].

Весной 2010 года эпизоотия чумы выявлена в урочищах «Коныр» и «Нарбай» и характеризовалась как локальная, малоинтенсивная и протекала на общей площади 200 км². Осенью 2010 года локальная, малоинтенсивная эпизоотия чумы выявлена в урочищах Байгожа, Расылбек, «Жуантобе», в окр. аула Кошек батыр и на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 400 км² [12].

Весной 2011 года локальная, малоинтенсивная эпизоотия чумы выявлена серологическим методом в окр. аула Кошек батыр, урочищах «Майнеке», «Буровая», «Аккесене» и в окр. а. Акатай и характеризовалась как локальная малоинтенсивная протекала на общей площади 500 км² [13].

Весной 2012 года локальная, малоинтенсивная эпизоотия чумы выявлена в окр. п. «Ушарал», урочищах «Жуантобе», «Аккудык», «Кожекудык», «Жангызтатты». Эпизоотия характеризовалась как локальная малоинтенсивная и протекала на общей площади 500 км². Осенью 2012 года локальная интенсивная эпизоотия чумы выявлена на общей площади 600 км²: в ур. «Токтыкора» обнаружена 1 серопозитивная большая песчанка, в ур. «Сарсенбай» обнаружена 1 серопозитивная большая песчанка, в ур. «Бақытжан» обнаружены 2 серопозитивные большие песчанки, в ур. «Майнеке» - 2 серопозитивные большие песчанки; в ур. «Шешенкудык» - 1 серопозитивная большая песчанка; в ур. «Коралы-как» выделены 3 культуры возбудителя чумы от эктопаразитов, снятых с большой песчанки: блох *Nosopsyllus laeviceps* - 10 экз., клещей *Haemaphysalis erinacei* - 10 экз. и *Ornithodoros tartakovskyi* - 4 экз. [14].

Весной 2013 года эпизоотия чумы выявлена серологическим методом в урочищах «Шитис» и «Атбайлар-2». Эпизоотия чумы на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 200 км². Осенью 2013 г. локальная малоинтенсивная эпизоотия чумы выявлена в ур. «Бапак». Эпизоотия чумы на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 100 км² [15].

Весной 2014 года эпизоотия чумы выявлена в урочищах «Уштобе», «32-квартал», «Ферма №4»

(Ушарал). Эпизоотия чумы на всех участках характеризовалась как локальная, малоинтенсивная и протекала на общей площади 300 км² [16].

Весной 2015 года эпизоотический процесс зарегистрирован на площади 100 км². в окр. пос. «Ойык» изолированы 2 штамма *Y. pestis* от блох нор большой песчанки *Xenopsylla gerbilli minax*. Эпизоотия была зарегистрирована впервые и характеризовалась как локальная. интенсивная [17].

Весной 2019 года эпизоотический процесс зарегистрирован на общей площади 100 км² в ур. Торебек [18].

Осенью 2020 года эпизоотия чумы выявлена в ур. «Аккесене», где были выявлены 2 серопозитивные большие песчанки [19].

Материалы и методы. Отлов грызунов осуществлялся из 10-12 колоний большой песчанки. За рабочую неделю обследовалось не менее чем по 14 секторов.

Ловцы расставлялись в 1,5 км друг от друга. На одной колонии ставили 2-3 ловушки, для более равномерного обследования территории с каждой колонии отлавливалось, в среднем 1-2 песчанки, после чего ловушки переставлялись на не обловленные колонии. В первую очередь обследование проводилось в окрестностях населенных пунктов, по секторам. Большие песчанки учитывались маршрутно-колониальным методом, а малые песчанки и другие мелкие мышевидные грызуны методом ловушка – ночей.

Отлов большой, краснохвостой песчанок проводился ловушками, выставленными у входа нор этих грызунов. На одной колонии отлавливали не более 2-х песчанок, после чего ловушки переставляли на другие колонии.

Учеты численности малых песчанок проводились по возможности на 50% точках забора материала путем выставления 100 ловушек со стандартной приманкой (хлеб, смоченный растительным маслом) по основным биотопам в линию с интервалом в 5 метров, а также ловушками, выставленными на колониях больших песчанок.

Учеты желтых сусликов проводили на авто маршрутах (число встреч на 1 км пути). Малых тушканчиков учитывали в сумеречное время в свете фар автомобиля (число встреч на 1 или 10 км маршрута).

Численность мышевидных грызунов определяли методом ловушка-ночей. При учетах в населенных пунктах под обследование брали не менее 20 % общего числа объектов. Небольшие населенные пункты до 20 домов обследовались полностью. Одновременно с учетом численности грызунов проводили учет четвероногих хищников по попаданию их в ловушки, выставленные на колониях больших песчанок.

О численности пернатых хищников судили по числу птиц, замеченных за световой день.

Для проведения стационарных наблюдений над большой песчанкой выбраны 3 стационарные точки, которые наиболее полно отражали ландшафтно-экологическую особенность обследуемой территории. На стационарных точках постоянного

учета помимо обычных обследований проводились следующие экологические наблюдения:

а/ наблюдения за составом популяции грызунов и интенсивностью размножения;

б/ подсчет числа эмбрионов у беременных самок;

в/ регистрация повторной беременности и регрессии эмбрионов;

г/ изучение многолетней динамики численности большой песчанки;

д/ некоторые другие экологические наблюдения (смена колоний, межвидовые контакты, подвижность грызунов).

Характеристика погодных условий учитывалась по данным метеостанции, расположенной в поселке Ойык.

Результаты

За период работы обследование проведено на площади 5300 км². Весной 2021 г. на территории ЛЭР обследовано 53 сектора из них с забором материала 28 секторов.

Численность больших песчанок в среднем составила 249 на 1 км², при обитаемости колоний – 37,8 %. Плотность колоний на 1 км² – 152. Среднее число большой песчанки на 1 колонию – 4,4 особи. Межвидовой контакт грызунов низкий. Процент попадания второстепенных грызунов в ловушки составил 0,3 % на 100 ловушко-ночей.

За период исследований отловлено 304 грызунов, в том числе – большая песчанка 292, краснохвостая песчанка – 1, малый тушканчик – 2, домовая мышь – 9 особей.

Большая песчанка (*Rhombomys opimus* (Lichtenstein, 1823)) в Центральном азиатском пустынном очаге является основным носителем возбудителя чумы. Численность грызуна определяется до выхода молодняка [20]. На территории Южного придолинного ЛЭР зимний период пережило 54,1 % зверьков, что послужило снижению численности основного носителя на большей части ЛЭР.

За летний сезон 2021 г. На территории Южного Придолинного ЛЭР было отловлено 292 большие песчанки, из них половозрелых самцов – 96 (37,5 %), половозрелых самок – 163 (62,9 %). Из половозрелых самок, яловых самок – 46 (28,2 %), оценившихся – 102 (62,5 %), беременных самок было всего – 15 (9,2 %); молодых было отловлено – 33 (29,9 %), из них молодых самцов – 22 (66,6 %), молодых самок – 11 (33,3 %).

Соотношение половозрелых самок к самцам, составило 1,7:1. Процент самок, участвующих в размножении – 71,8%. Число эмбрионов на одну беременную самку в среднем было – 4,8, при колебании от 1 до 3. Наиболее интенсивное размножение наблюдалось в первой декаде июня. Летом 2021 г. показатель интенсивности размножения большой песчанки составил 47, весной прошлого года 280 соответственно.

Малые песчанки учитывались путем выставления 100 ловушек в линию на ночь.

Численность полуденной песчанки (*Meriones meridianus* (Pallas, 1773)) на территории в целом низкая, процент попадания составил 0 на 100 л/н.

Численность краснохвостой песчанки (*Meriones libycus* (Lichtenstein, 1823)) летом 2021 года была низкой. За период исследований была отловлена всего одна краснохвостая песчанка.

Численность гребенщиковой песчанки (*Meriones tamariscinus* (Illiger, 1811)) на территории в целом очень низкая. Процент их попадания на 700 л/н составил – 0%.

Численность тушканчиков была отмечена на низком уровне. Процент попадания в орудия лова составил 0,3 на 100 л/н. В сумеречное время на маршрутах встречались единичные зверьки, на 10 км автомаршрута было встречено 12 экземпляров малого тушканчика (*Allactaga elater* (Lichtenstein, 1825)) или 1,2 % особи на 1 км.

Численность желтого суслика (*Spermophilus fulvus* (Lichtenstein, 1832)) на территории ЛЭР была ниже средней. Специально сусликов не отлавливали. Для учета численности сусликов были заложены 3 маршрута, общая площадь которых составила 3 км². Всего было встречено 20 зверьков, в среднем приходилось 0,2 особи на 1 км².

При проведении учетов в ночное время на 6 авто маршрутах протяженностью 50 км каждый, из четвероногих хищников было встречено 3 лисицы (*Vulpes vulpes* (Linnaeus, 1758)), 1 волк (*Canis lupus* (Linnaeus, 1758)). Учитывая данные, полученные от местного населения и работников лесхоза, отмечена концентрация наземных хищников вокруг жилья человека.

Численность пернатых хищников по-прежнему, остается низкой. Из хищных птиц встречался канюк-курганник (*Buteo rufinus* (Cretzschmar, 1827)), на 10 км авто маршрута отмечено в среднем 2-4 птицы. Численность их остается низкой. Редко встречались лунь луговой (*Circus pygargus* (Linnaeus, 1758)), пустельга (*Falco tinnunculus* (Linnaeus, 1758)) и сыч домовый (*Athene noctua* Scopoli, 1769).

Таким образом, численность большой песчанки – основного носителя возбудителя чумы летом 2021 года в целом была на низком уровне и составила – 242 особи на 1 км², при обитаемости колоний – 37,3 %. Показатель интенсивности основного носителя составил 47. Среднее число эмбрионов на одну беременную самку составило 4,8. Исходя из вышеизложенного, на территории ЛЭР протекание эпизоотического процесса осенью 2021 года возможно в виде локальных эпизоотий.

Зима 2020-2021 гг. была малоснежной с редкими осадками в виде снега (18 дней). Температурный фон зимы был близок к средним многолетним данным и был -8,4. Весна была относительно прохладной и затяжной.

В 1 декаде марта температурный фон составил +4,1⁰ С, во 2-й декаде месяца -1,1⁰ С. В 3 декаде месяца и средняя температура воздуха составила +8,3⁰ С тепла. Среднемесячная температура воздуха составила +3,8⁰, в прошлом году +7,0⁰ С, при норме +1,7⁰ С. Выпадение осадков в виде дождя в 1-й, 2-й, 3-ей декаде (11 дней). Снежный покров на поверхности почвы отмечен до 20 марта, тогда как в прошлом году до лежал до 7 февраля. Переход через 0⁰

С к положительным температурам отмечен 19 марта, (в прошлом году – 13 февраля).

В апреле месяце погода была устойчивой, в пределах многолетних значений. Температура воздуха в первой декаде была $+10,7^{\circ}\text{C}$, во второй декаде $+15,1^{\circ}\text{C}$, в третьей декаде $+16,7^{\circ}\text{C}$. Осадки выпадали в виде дождя во второй и в третьей декаде месяца (сопровождаясь сильными восточным ветром в первой, во второй декаде). В первой, второй и третьей декаде апреле отмечалось редкое цветение тюльпанов. В третьей декаде апреля отмечено редкое цветение маков. Оценка состояния растительности была низкой в связи со слабой вегетацией эфемеров и эфемероидов. В целом погодные условия апреля месяца, были благоприятными для жизнедеятельности грызунов.

В мае месяце погода была устойчивой, умеренно-теплой, но ветреной, в основном преобладали сильные ветра восточного направления. Осадки выпадали в первой, во второй декаде месяца (3 раза). Температура воздуха в первой декаде $+21,3^{\circ}\text{C}$, во второй $+23,0^{\circ}\text{C}$ и в третьей $+28,4^{\circ}\text{C}$. Оценка состояния растительности была неудовлетворительной, слабо вегетировали эфемеры и эфемероиды, плохо произрастала полынь и ковыль, скудное цветение маков продолжалось до третьей декады мая.

В целом можно сказать, что весна 2021 года была поздней и засушливей весны предыдущего года. Кормовая база для грызунов была недостаточной в связи со слабой вегетацией пустынной растительности, климатические условия были удовлетворительными и достаточными для жизнедеятельности грызунов.

Учитывая результаты проведенных исследований, можно предположить, что к осени 2021 года численность большой песчанки в целом по территории Южного придолинного ЛЭР при благоприятных погодно-климатических условиях будет несколько увеличиться.

Учитывая данные по численности малых песчанок, межвидовому контакту их с большой песчанкой, можно сказать, что их численность гребенщиковой, полуденных, так и краснохвостых песчанок, осенью 2021 г. останется низкой, а численность малого тушканчика осенью 2021 года незначительно увеличится.

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CHEMICAL SCIENCES

PHYSICO-CHEMICAL INVESTIGATION OF PHASE EQUILIBRIUM AND GLASS FORMATION IN THE As_2Se_3 - TlGaS_2 SYSTEM

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Abstract

Phase equilibrium and glass transition in the As_2Se_3 - TlGaS_2 system were studied by methods of physico-chemical analysis: differential thermal analysis (DTA), X-ray diffraction analysis (XRD), microstructural analysis (MSA), as well as density and microhardness measurements; its phase diagram was constructed. It has been established that the As_2Se_3 - TlGaS_2 system is a quasi-binary part of the quasi-ternary system As_2Se_3 - Ga_2S_3 - Tl_2S and belongs to the eutectic type. The composition of the binary eutectic formed in the system is 15 mol % TlGaS_2 , temperature is 290°C. Based on the results of microstructural analysis, it was established that in the As_2Se_3 - TlGaS_2 system, solid solutions based on As_2Se_3 containing 2.5 mol % TlGaS_2 at room temperature, and based on TlGaS_2 solid solutions is 6.5 mol % As_2Se_3 . The glass formation region based on As_2Se_3 extends to 25 mol % TlGaS_2 with slow cooling.

Keywords: system, phase equilibrium, quasi-binary, density, glass

Introduction

It is known that arsenic chalcogenides are semiconductor compounds obtained in glass form under normal conditions. Recently there has been some interest in complex chalcogenide compounds. First of all, the broad study of the chemistry and physics of arsenic chalcogenide compounds is associated with the expansion of their practical application.

Arsenic chalcogenides and compounds based on them, as well as glassy alloys, are materials with high photoelectric [1-6], luminescent [7,8] and acousto-optical [9] properties. In recent years, chalcogenide fibers [10–12] based on As_2S_3 and As_2Se_3 have been used to transmit light in the mid-IR range and have found application as a compact nonlinear medium allowing Raman amplification [13] and laser lasing [14]. Compounds of the TlGaX_2 (X-S, Se, Te) type are also photosensitive materials and are widely studied [15–17]. A number of systems including TlGaX_2 compounds have been studied in the literature [18–22].

The purpose of this work is to construct a T-x phase diagram and identify regions of solid solutions based on the study of phase equilibria and glass transition in the As_2Se_3 - TlGaS_2 system.

The As_2Se_3 compound melts congruently at 381°C and crystallizes in a monoclinic syngony with a lattice parameter $a = 12.053$; $b = 9890$; $c = 4.277$ Å, $\alpha = 90^\circ 28'$, sp.gr. P21/n has a glass density $\rho = 4.62$ g/cm³, microhardness $H_\mu = 140$ MPa, crystal density $\rho = 5.21$ g/cm³, microhardness $H_\mu = 75$ MPa [23]. The TlGaS_2 compound melts congruently at 905°C and crystallizes in the tetragonal syngony, lattice parameters: $a = 7.29$ Å, $c = 29.90$ Å, $z = 16$, density 5.64 g/cm³, microhardness 700 MPa [24].

Experimental part

Alloys of the As_2Se_3 - TlGaS_2 systems were synthesized from the As_2Se_3 and TlGaS_2 components by fusing in quartz ampoules in the temperature range 700–

1000°C at a pressure of 0.133 Pa. After synthesis, the alloys were subjected to heat treatment at a temperature of 280°C for 240 hours to homogenize them. Then the alloys of the As_2Se_3 - TlGaS_2 system were studied by methods of physicochemical analysis: differential thermal analysis (DTA), X-ray diffraction (XRD), microstructural analysis (MSA), as well as methods of measuring density and microhardness.

Differential-thermal analysis (DTA) was carried out using a TERMOSCAN-2 thermograph. The Al_2O_3 compound was taken as standard, the heating rate was 5 min/min.

X-ray phase analysis was performed on a D2-PhASER X-ray diffractometer. The study used $\text{CuK}\alpha$ radiation and a Ni filter. Microstructural analysis (MSA) was carried out on a MIM-8 microscope. To do this, the alloys were polished and given shine, and their structure was examined under a microscope. To clarify the phase boundaries, a solution of 10 ml KOH + 5 ml $\text{C}_2\text{H}_5\text{OH}$ was used as an etchant. Microhardness was measured with a PMT-3 metallographic hardness tester. The compositional dependence of microhardness for each phase was measured. The density of the samples was determined by the pycnometric method; Toluene was used as a filling solution.

Results and its discussion

Alloys of the As_2Se_3 - TlGaS_2 system with a concentration of 0–25 mol % TlGaS_2 are glassy, and the remaining alloys are crystalline substances. Glassy alloys based on the As_2Se_3 compound in the range of 0–25 mol % TlGaS_2 was heat treated at 220°C for 580 hours for crystallization. Then the alloys of the system were studied by methods of physicochemical analysis.

The results of differential-thermal analysis show that the endothermic effects obtained from the thermograms of the alloys are accompanied by a softening temperature T_g in the glass region. Two endothermic effects are observed in the thermograms of alloys.

As a result of microstructural analysis of the alloys, it was established that near the As_2Se_3 and TlGaS_2 compounds, single-phase alloys are present in the sys-

tem, and the remaining alloys are two-phase. Microstructures of alloys of the As_2Se_3 - TlGaS_2 system containing 20, 60 and 92.5 mol % TlGaS_2 are presented in Fig. 1.



Fig. 1. Microstructures of alloys of the As_2Se_3 - TlGaS_2 system. 1-20 mol %, 2-60 mol %, 3-92.5 mol % TlGaS_2 .

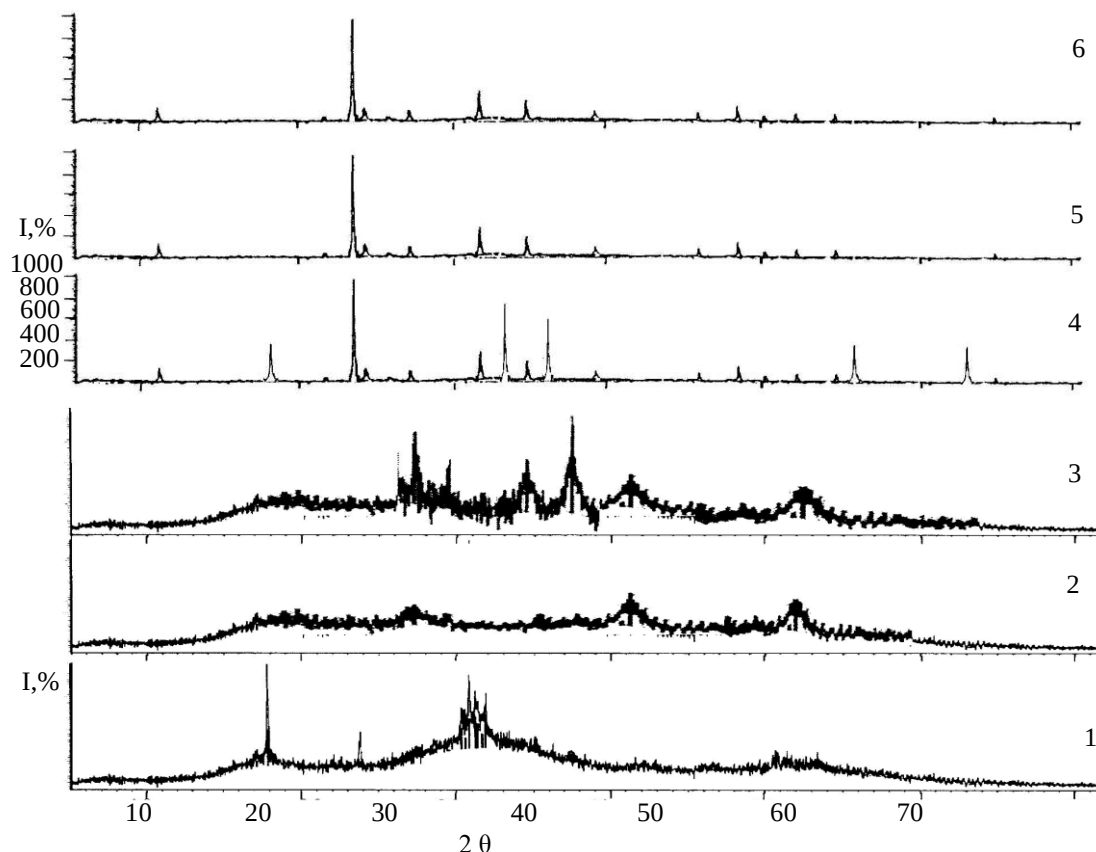


Fig. 2. Diffraction patterns of alloys of the As_2Se_3 - TlGaS_2 system. 1- As_2Se_3 , 2- 10, 3-25, 4-60, 5- 93, 6-100 mol % TlGaS_2 .

A sample with a concentration of 20 mol % TlGaS_2 is a glassy alloy which is a single phase. A sample containing 60 mol % TlGaS_2 is a two-phase alloy. Single-phase sample containing 93.5 mol % TlGaS_2 , are solid solutions based on the TlGaS_2 compound.

X-ray phase analysis of alloys of the As_2Se_3 - TlGaS_2 system containing 10, 25, 60 and 93.5 mol % TlGaS_2 are presented in Fig. 2. It has been established that alloys containing 10 and 25 mol % TlGaS_2 , are glassy; no diffraction lines were obtained in their diffraction patterns. Diffraction lines in the diffraction pattern of the alloy 60 mol % TlGaS_2 are a mixture of diffraction lines of the original components, i.e. it is a two-

phase alloy. X-ray diffraction pattern of the alloy 93.5 mol % TlGaS_2 is identical to the TlGaS_2 compound, i.e. the sample is a solid solution based on the TlGaS_2 compound.

Thus, X-ray phase analysis confirms the results of DTA and microstructural analysis.

The T-x phase diagram of the As_2Se_3 - TlGaS_2 system was constructed based on the results of physico-chemical analysis methods (Fig. 3). The phase diagram of the system is quasi-binary, eutectic type. The composition of the eutectic formed between the compounds As_2Se_3 and TlGaS_2 is 15 mol % TlGaS_2 , temperature 280°C.

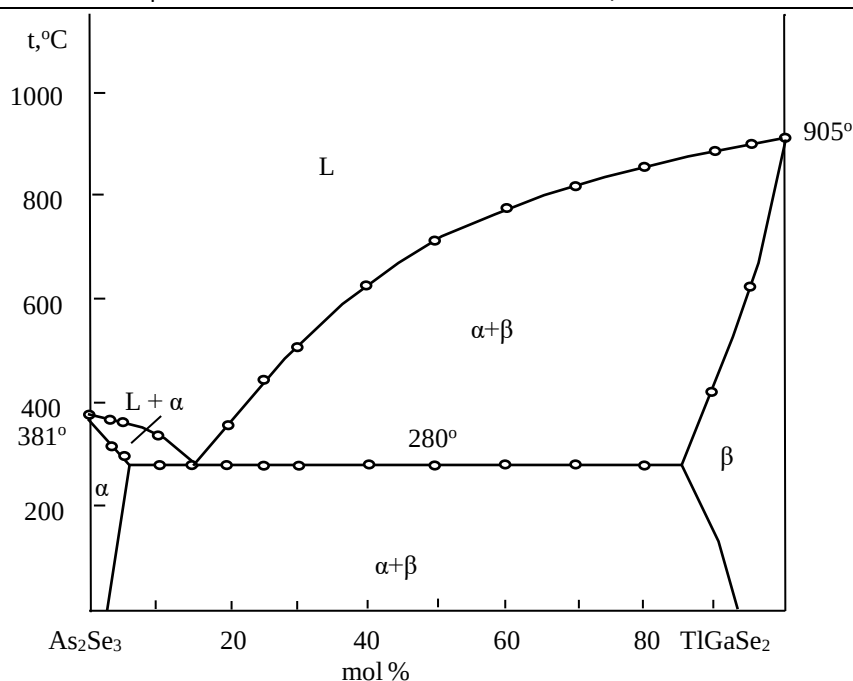


Fig.3. *T-x phase diagram of the As_2Se_3 - TlGaSe_2 system.*

The liquidus of the As_2Se_3 - TlGaSe_2 system consists of the initial crystallization curves of the α -solid solution formed based on the As_2Se_3 compound and the β -solid solution based on TlGaSe_2 . In the system at room temperature, the solubility based on the As_2Se_3 compound reaches 2.5 mol % TlGaSe_2 , and solid solutions based on the TlGaSe_2 compound is 6.5 mol % As_2Se_3 . In the As_2Se_3 - TlGaSe_2 system, two-phase alloys consisting of (α + β) crystallize below the solidus line.

The dependence of the microhardness of alloys of the As_2Se_3 - TlGaSe_2 system on composition has been studied and it has been established that there are two different values of microhardness. Some physicochemical properties of alloys 0–25 mol % TlGaSe_2 in the glass

area is given in Table 1. Some physicochemical properties of the system after heat treatment of alloys of the As_2Se_3 system at a temperature of 220°C for 580 hours are given in Table 2. The microhardness of glassy alloys based on the As_2Se_3 composition varies in the range (1400–1470) MPa, and their density is in the range of 4.62–5.40 g/cm³ (Table 1). The microhardness of α -solid solutions based on the As_2Se_3 crystalline state of all alloys of the system varies within the range of (750–830) MPa, and the microhardness value (700–780) MPa corresponds to the microhardness of β -solid solutions based on TlGaSe_2 (Table 2). After crystallization of alloys containing 0–25 mol % TlGaSe_2 the softening temperature disappears, but the temperature effect of liquidus and solidus remains.

Table 1.

Composition of alloys of the As_2Se_3 - TlGaSe_2 system, results of DTA, measurements of density and microhardness (glassy state)

Composition, mol %		Thermal effects, °C	Density, q/sm ³	Microhardness, MPa	
As ₂ Se ₃	TlGaS ₂			α	β
				P=0,10 N	P=0,15 N
100	0.0	140,381	4,62	1400	—
97	3,0	140,320,380	4,65	1450	—
95	5,0	145,290,375	4,67	1470	—
90	10	150,280,370	4,72	1470	—
85	15	150,280	4,77	1470	—
80	20	155,280,340	4,83	1470	—
75	25	155,280,440	4,87	1470	780

Table 2.

Composition of alloys of the As₂Se₃-TlGaS₂ system, results of DTA, density and microhardness measurements (in crystalline form)

Composition, mol %		Thermal effecns, °C	Density, q/sm ³	Microhardness, MPa	
As ₂ Se ₃	TlGaS ₂			α	β
				P=0,10 N	P=0,15 N
100	0.0	381	5,21	750	—
97	3,0	320,380	5,23	790	—
95	5,0	290,375	5,25	830	—
90	10	280,370	5,26	830	
85	15	280	5,27	Eutek.	Eutek.
80	20	280,340	5,30	—	780
75	25	280,440	5,33	—	780
70	30	280,510	5,34	—	780
60	40	280,625	5,38	—	780
50	50	280,710	5,42	—	780
40	60	280,775	5,46	—	780
30	70	280,815	5,51	—	780
20	80	280,850	5,55	—	780
10	90	420,880	5,62	—	780
5,0	95	625,900	5,66	—	750
0,0	100	905	5,64	—	700

Conclusion

Phase equilibrium and glass formation in the As₂Se₃-TlGaS₂ system were studied using complex methods of physical and chemical analysis: differential thermal analysis (DTA), X-ray diffraction analysis (XRD), microstructural analysis (MSA), as well as measuring microhardness and density and constructing its phase diagram. It has been established that the phase diagram of the As₂Se₃-TlGaS₂ system is quasi-binary and eutectic. The binary eutectic formed between the compounds As₂Se₃ and TlGaS₂ has a composition of 15 mol % and temperature 280°C. It has been established that the area of the solid solution at room temperature based on the As₂Se₃ compound is 2.5 mol % TlGaS₂, and the solubility based on the TlGaS₂ compound is 6.5 mol % As₂Se₃. During slow cooling in the As₂Se₃-TlGaS₂ system based on As₂Se₃, the glass transition region expands to 25 mol % TlGaS₂.

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PHYSICAL-CHEMICAL INVESTIGATION OF CHEMICAL INTERACTION AND GLASS FORMATION IN THE TlAsSe_2 -InSe SYSTEM

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Abstract

Using physicochemical methods of analysis: differential thermal analysis (DTA), X-ray diffraction (XRD), microstructural analysis (MSA), as well as by measuring density and microhardness, chemical interactions and glass formation in the TlAsSe_2 -InSe system were studied and a T-x phase diagram was constructed. It has been established that the phase diagram of the TlAsSe_2 -InSe system is a quasi-binary section of the quasi-ternary Tl_2Se - As_2Se_3 -InSe system and is eutectic. The composition of the eutectic formed between the TlAsSe_2 and InSe compounds in the system is 20 mol % InSe, temperature 170°C. In the system at room temperature, solid solutions based on TlAsSe_2 reach 5 mol % InSe, and solid solutions based on InSe amount to 2.5 mol % TlAsSe_2 . The glass formation regions based on TlAsSe_2 extend up to 20 mol % InSe.

Keywords: glass formation, quasi-binary, eutectic, microhardness, phase diagram.

Introduction

The TlAsSe_2 component included in the TlAsSe_2 -InSe system is obtained from the As_2Se_3 and Tl_2Se compounds. These components that made up the system were materials with functional properties. Arsenic chalcogenides are widely used as photosensitive [1-5] and luminescent [6,7] materials in optical systems. In recent years, glassy chalcogenide fibers based on arsenic chalcogenides have found application as a compact nonlinear medium providing efficient Romanov amplification and lasing, pulse compression, optical regeneration, and wavelength conversion [8–10]. Thallium compounds with ternary chalcogenide phases obtained on their basis are photosensitive semiconductors in the visible region of the spectrum [11,12]. The InSe compound, its ternary compounds and solid solutions are semiconductor materials with photosensitive and thermoelectric properties [13,14]. Many systems consisting of arsenic chalcogenides have been studied in the literature [15–20]. From this point of view, alloys of complex composition obtained by chemical interaction of TlAsSe_2 and InSe compounds can also be photosensitive materials.

The TlAsSe_2 compound melts congruently at 265°C, its microhardness is 920 MPa, $T_g=100^\circ\text{C}$ [21]. The InSe compound melts congruently at 660°C and crystallizes in the hexagonal syngony, lattice parameter: $a = 0.405\text{ nm}$, $c = 1.693\text{ nm}$, space gr. P63/mmc has a density of 5.56 g/cm^3 [22].

Experimental part

Alloys of the TlAsSe_2 -InSe system were synthesized from the TlAsSe_2 and InSe components by co-melting in quartz ampoules, evacuated to a pressure of

0.133 Pa in the temperature range 500–800°C. To bring the alloys to equilibrium, they were subjected to heat treatment at a temperature of 170°C for 350 hours. Then the alloys of the system were studied by DTA, X-ray diffraction analysis, MSA, density and microhardness measurements.

Differential thermal analysis was carried out using a TERMOSCAN-2 device. The heating rate of the alloys was 5 degrees/min. Chromel-alumel was used as a thermocouple.

X-ray phase analysis of the alloys was carried out on a D2 PHASER X-ray diffractometer. A $\text{CuK}\alpha$ electrode was used as an irradiator. Microhardness was measured using a PMT-3 metallographic microscope. Microstructure analysis was carried out using a MIM-8 microscope. When determining the densities of the system alloys, the pycnometric method was used and toluene was used as a filling solution.

Results and its discussion

In the TlAsSe_2 -InSe system, alloys obtained in the range of 0–20 mol % InSe is glassy, and the remaining alloys are dark gray substances obtained in the form of crystals. During the differential thermal analysis of the alloys, it was established that two endothermic effects are observed in the thermograms of the samples. It has been established that in the thermograms of alloys in the concentration range of 0–20 mol % InSe has a softening temperature $T_g = 100^\circ\text{C}$, characteristic of glasses. When studying the microstructure of alloys of the TlAsSe_2 -InSe system, single- and two-phase regions were discovered. In Fig. 1 shows the microstructures of alloys of the TlAsSe_2 -InSe system with a content of 5, 60 and 97.5 mol % InSe.



Figure 1. Microstructures of TlAsSe_2 -InSe system alloys. 1-5 mol %, 2-60 mol %, 5-97.5 mol % InSe.

As can be seen from the microstructure, single-phase samples 5 and 97.5 mol % InSe are solid solution alloys based on TlAsSe_2 and InSe compounds, respectively. Sample 60 mol % InSe is a two-phase field alloy.

To clarify the results of microstructural and differential thermal analysis, X-ray phase analysis of alloys containing 5, 10, 20, 60 and 97.5 mol % InSe (Fig. 2).

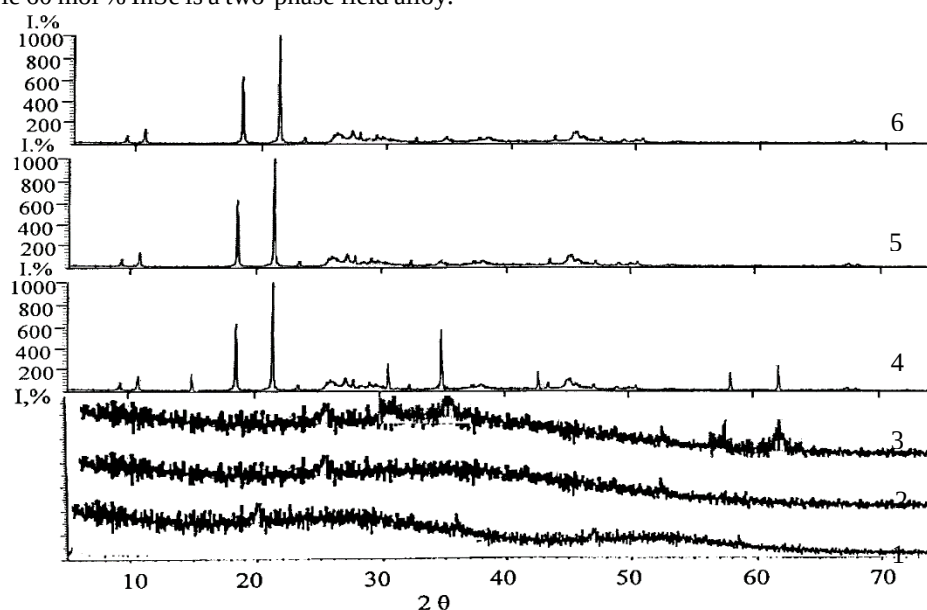


Fig. 2. X-ray diffraction patterns of alloys of the TlAsSe_2 -InSe system. 1- TlAsSe_2 , 2-5, 3-10, 4-20, 5-93 mol %, 6-100 mol % InSe.

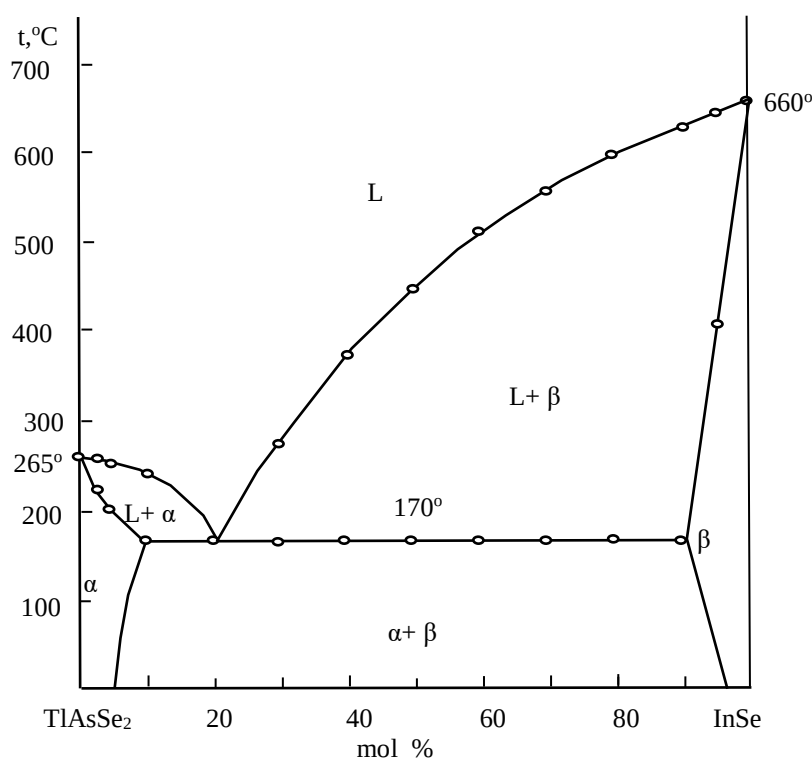


Fig. 3. T-x phase diagram of the TlAsSe_2 -InSe system.

It was found that samples containing 5, 10, 20 mol % InSe are glassy. Existing diffraction lines in the diffraction pattern of the 60 mol % InSe alloy is a mixture of diffraction lines of TlAsSe_2 and InSe compounds, that is, it is a two-phase alloy. Diffraction lines of a sample containing 97.5 mol % InSe are identical to the diffraction lines of the InSe compound, that is, they are solid solutions based on InSe. The T-x phase diagram of the TlAsSe_2 -InSe system was constructed based on the results of physicochemical analysis methods (Fig.

3). The TlAsSe_2 -InSe system is quasi-binary and eutectic. The composition of the eutectic formed between the TlAsSe_2 and InSe compounds is 20 mol % InSe, temperature 170°C. In a system at room temperature, the region of solid solution based on the TlAsSe_2 compound is 5 mol % InSe, and the base InSe is up to 2.5 mol % TlAsSe_2 . In the TlAsSe_2 -InSe system, upon slow cooling based on TlAsSe_2 , the glass transition regions expand to 20 mol % InSe.

liquidus of the TlAsSe_2 -InSe system consists of the primary crystallization curves of an α -solid solution based on the TlAsSe_2 compound and a β -solid solution based on InSe. Two-phase alloys consisting of (α + β) crystallize below the solidus line in the system.

When measuring the microhardness of alloys of the TlAsSe_2 -InSe system, two different values were obtained. The microhardness of α -solid solutions obtained

based on the TlAsSe_2 compound varies within the range (920-1050) MPa. The microhardness of β -solid solutions based on the InSe compound varies within the range (600-680) MPa. Table 1 shows some physico-chemical properties of alloys of the TlAsSe_2 -InSe system after heat treatment.

Table 1.

Composition of alloys of the TlAsSe_2 -InSe system, results of DTA, density and microhardness measurements.

Composition, mol %		Thermal effects, °C	Density, q/cm ³	Microhardness, MPa	
TlAsSe ₂	InSe			δ	α
				P=0,10 N	P=0,15 N
100	0.0	265	7,45	920	–
97	3,0	225,265	7,46	1050	–
95	5,0	200,250	7,40	1050	–
90	10	170,240	7,27	–	–
80	20	170	7,07	Eutek.	Eutek.
70	30	170,275	6,88	–	–
60	40	170,370	6,66	–	680
50	50	170,440	6,50	–	680
40	60	170,510	6,32	–	680
30	70	170,560	6,12	–	680
20	80	170,600	5,94	–	680
10	90	170,625	5,74	–	680
5,0	95	410,650	5,65	–	670
0.0	100	660	5,56		600

Conclusion

The T-x phase diagram of the TlAsSe_2 -InSe system was constructed based on the results of physico-chemical analyses. The phase diagram of the system is quasi-binary, eutectic type. Cocrystallization of TlAsSe_2 and InSe compounds ends at the double eutectic point of composition 20 mol % InSe, temperature 170°C. In the TlAsSe_2 -InSe system at room temperature, solid solutions based on the TlAsSe_2 compound reach 5 mol % InSe, and based on InSe compounds - up to 2.5 mol % TlAsSe_2 . In the TlAsSe_2 -InSe system, upon slow cooling based on the TlAsSe_2 compound, the glass transition region expands to 20 mol % InSe.

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PHYSICO-CHEMICAL INVESTIGATION OF PHASE EQUILIBRIUM IN THE SrIn_3 -SrSe SYSTEM**Sultanova A.,***Doctoral student***Yagubov N.,***Doctor of Chemistry, prof.**Baku State University***Aliyev I.,***Doctor of Chemistry, prof. hands. lab.**Institute of Catalysis and Inorganic Chemistry named after M.F.Nagiyev
of the Ministry of Science and Education of the Republic of Azerbaijan***Ahmedova C.,***Ph.D., Associate Prof**Adiyaman University, Faculty of Arts and Sciences,**Department of Chemistry, Turkey***Qafarova G.***Researcher**Institute Physics of the Ministry of Science and Education
of the Republic of Azerbaijan*<https://doi.org/10.5281/zenodo.11390460>**Abstract**

The phase equilibrium in the SrIn_3 -SrSe system was studied using complex methods of physicochemical analysis: differential thermal analysis (DTA), X-ray diffraction analysis (XRD), microstructural analysis (MSA), as well as density and microhardness, and a T-x phase diagram was constructed. It has been established that the phase diagram of the SrIn_3 -SrSe system is a partially quasi-binary cross section of the Sr-In-Se ternary system. It has been established that eutectic equilibrium and peritectic transformation take place in the system. A microstructural analysis of the alloys of the system was carried out and it was found that at room temperature solid solutions based on the SrSe compound reach 3 mol % SrIn_3 , and solid solutions based on SrIn_3 are practically not established.

Keywords: phase equilibrium, quasi-binary, eutectic, peritectic, density

Introduction

Elements of main subgroup II are chemically very active substances and react with strong heat release with chalcogenides. Therefore, when reacting these elements with chalcogenides, it is necessary to take into account temperature conditions. Meanwhile, calcium chalcogenides and ternary systems based on them have been studied in many more systems than strontium and barium chalcogenides. Chalcogenides of elements of the calcium subgroup and ternary systems based on them were studied by the authors of works [1-4]. Systems based on strontium and barium chalcogenides have been little studied. Compounds such as $\text{A}^{\text{II}}\text{MeX}_2$, $\text{A}^{\text{II}}\text{Me}_2\text{X}_4$ (A^{II} -Ca,Sr; Me-Ga,In; X-S,Se,Te) exhibit strong luminescent properties due to the action of activators [5-7].

Previously, we studied a series of Ca-Ga(In)-Se ternary systems [8-10]. The SrIn_3 -SrSe system has not been studied.

The purpose of this work is to study phase equilibria in the SrIn_3 -SrSe system, construct its phase diagram and detect solid solution regions.

The SrIn_3 compound is an intermetallic compound, melts incongruently at 540°C and crystallizes in the hexagonal syngony, lattice parameters: $a = 6.69 \text{ \AA}$; $c = 5.481 \text{ \AA}$ sp. gr. $\text{P6}_3/\text{mmc}$ [12]. The SrSe compound melts congruently at 1600°C and crystallizes in the cubic syngony, with lattice parameters: $a = 6.243 \text{ \AA}$, sp. gr. $\text{Fm}3\text{m}$, density $\rho = 4.50 \text{ g/cm}^3$ [13].

Experimental part

Alloys of the SrIn_3 -SrSe system were synthesized from the components SrIn_3 and SrSe in a quartz ampoule into which air was sucked to a pressure of 0.133 Pa in the temperature range 800 - 1200°C . The alloys were subjected to heat treatment for 240 hours at a temperature of 500°C to homogenize them. Equilibrium samples were studied by methods of physicochemical analysis (DTA, XRF, MCA, as well as density and microhardness measurements).

Differential thermal analysis of the samples was carried out on a Kurnakov pyrometer NTR-73. Al_2O_3 was used as a standard; the heating rate was 10 min/min.

X-ray phase analysis was performed on a D2 PHASER X-ray diffractometer. A $\text{CuK}\alpha$ cathode and a Ni filter were used as irradiators. Microhardness was calculated using a PMT-3 metallographic microscope. Microstructure analysis was carried out using a MIM-8 microscope. The density of the samples was determined by the pycnometric method using toluene as a filler.

Results and its discussion

Alloys of the SrIn_3 -SrSe system in the range of 0-60 mol % SrSe are compact masses and have a bright black color.

Differential thermal analysis of the alloys of the system shows that two and three endothermic effects are observed in their thermograms. A large number of thermal effects in the system indicates that a complex interaction is occurring.



Fig. 1. Microstructure of alloys of the $\text{SrIn}_3\text{-SrSe}$ system.
1-30 mol %, 2-70 mol %, 3-97 mol % SrSe.

By analyzing the microstructure, it was established that there are single-phase and two-phase alloys in the system. In Fig. 1 shows the microstructure of alloys containing 30, 70 and 97 mol % SrSe. As can be

seen from Figure 1, SrSe samples containing 30 and 70 mol. % are two-phase, while a single-phase sample containing 97 mol. % SrSe is a solid solution alloy based on the SrSe compound.

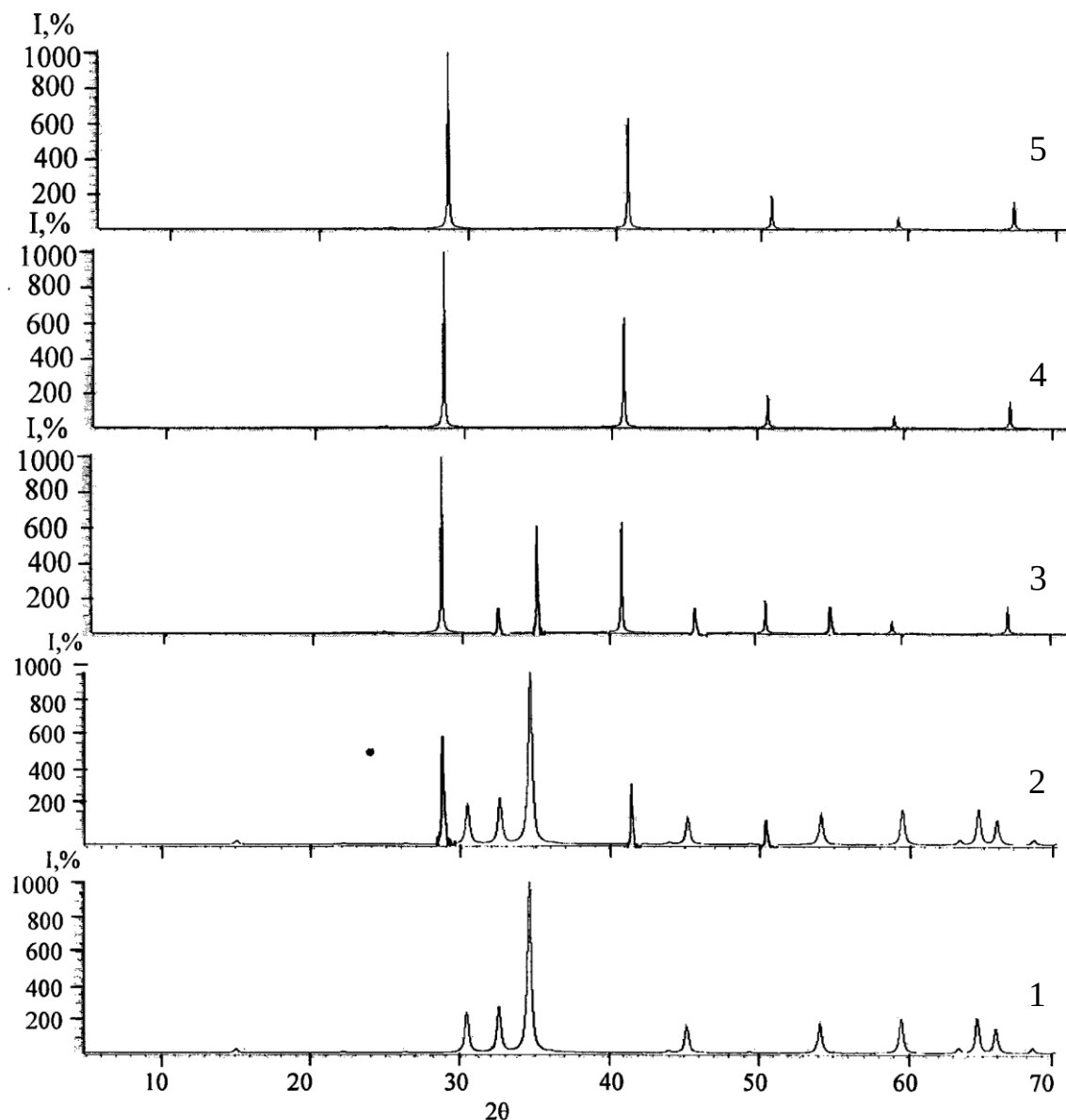


Fig. 2. X-ray diffraction patterns of the $\text{SrIn}_3\text{-SrSe}$ system.
1- SrIn_3 , 2-30, 3-70, 4-97, 5-100 mol % SrSe.

The results of DTA and microstructure analysis were monitored by X-ray diffraction analysis. For this purpose, X-ray diffraction analysis of alloys containing 30, 70 and 97 mol % SrSe (Fig. 2). As a result of X-ray diffraction analysis, it was established that in the diffraction patterns of alloys containing 30 and 70 mol % SrSe, a mixing of the diffraction lines of the SrIn_3 and SrSe compounds is observed. Diffraction lines present in the diffraction pattern of a sample containing 97 mol % SrSe are identical to the diffraction lines of the SrSe compound, that is, the sample is a solid solution alloy based on SrSe.

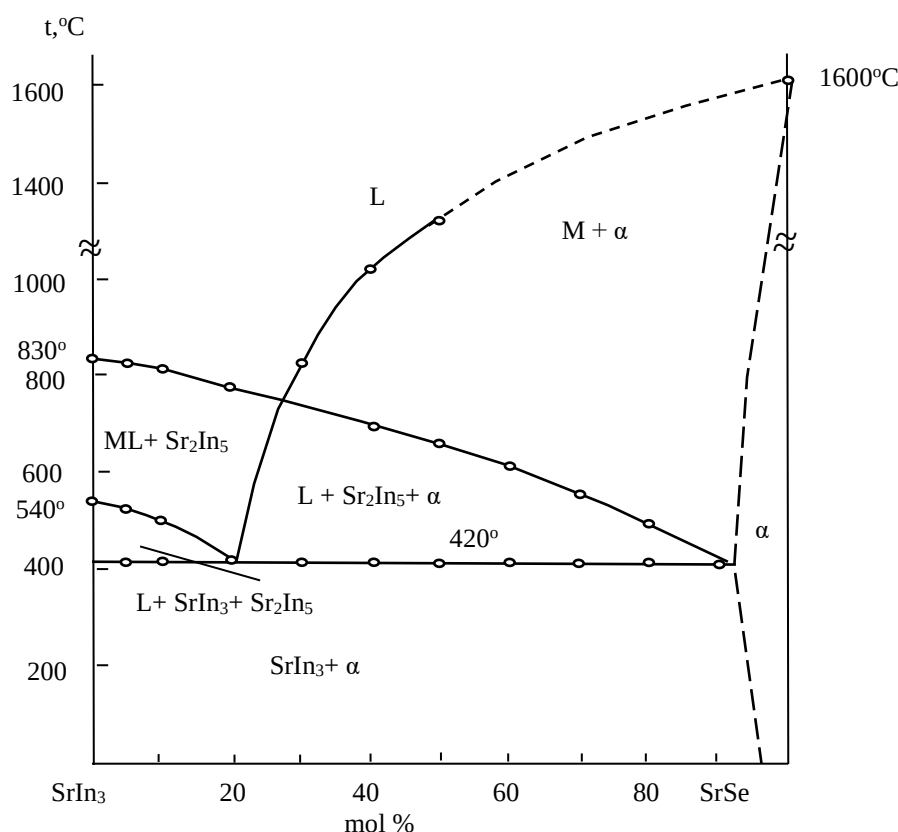


Fig.3. Phase diagram of the SrIn₃-SrSe system.

Thus, based on the results of physicochemical analysis methods, a phase diagram of the SrIn₃-SrSe system was constructed (Fig. 3). The phase diagram of the system is partially quasi-binary and is characterized by eutectic equilibrium and peritectic transformation. The SrIn₃-SrSe system is partially non-quasi-binary, since the SrIn₃ compound has a peritectic nature. In the system, the SrIn₃ compound is decomposed as follows: $\text{SrIn}_3 \leftrightarrow \text{M} + \text{Sr}_2\text{In}_5$.

The liquidus of the system is limited by the monovariant equilibrium curves of the Sr₂In₅ compound and the α-solid solution obtained on the basis of SrSe. In the system above the solidus line in the range of 0–97 mol % SrSe, a three-phase field is formed, consisting of (M + Sr₂In₅+SrIn₃) and (M+SrIn₃+α). Two-phase alloys consisting of (SrIn₃+α) crystallize below the solidus line. The system also undergoes peritectic transformations $\text{M} + \text{Sr}_2\text{In}_5 \leftrightarrow \text{SrIn}_3$ at 420°C.

Table 1.

Composition of alloys of the SrIn₃-SrSe DTA system, results of density and microhardness measurements

Composition, mol %		Thermal effects, °C	Density q/cm ³	Microhardness, MPa	
SrIn ₃	SrSe			SrIn ₃	α
				P=0,20 N	P=0,10 N
100	0.0	540, 830	5,24	1700	—
95	5,0	420,520,820	5,28	1700	—
90	10	420,500,800	5,22	1700	—
80	20	420,780	5,10	1700	—
70	30	420,825	5,02	1700	1280
60	40	420,700,1020	4,94	—	1280
50	50	420,660,1220	4,87	—	1280
40	60	420,610	4,79	—	1280
30	70	420,550	4,72	—	1280
20	80	420,500	4,65	—	1270
10	90	420	4,57	—	1270
0,0	100	1600	4,50	—	1250

As a result of measuring the microhardness of alloys of the SrIn₃-SrSe system, two different microhardness values were obtained. The microhardness value 1700 MPa corresponds to the microhardness value of

the SrIn₃ compound. The microhardness of α-solid solutions based on the SrSe composition ranges from 1250 to 1280 MPa.

Results

Using the methods of physicochemical analysis, the phase equilibrium in the SrIn₃-SrSe system was studied and its T-x phase diagram was constructed. It has been established that the SrIn₃-SrSe system is a partial quasi-binary cross section of the Sr-In-Se ternary system. Eutectic equilibrium and peritectic transformation are formed in the system. In the SrIn₃-SrSe system, the area of the solid solution based on the SrSe compound at room temperature is 3 mol %, and the region of the solid solution based on SrIn₃ is practically undefined.

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ECONOMIC SCIENCES

PRINCIPLES AND METHODS OF HUMAN RESOURCES DEVELOPMENT UNDER MODERN ECONOMIC CONDITIONS

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Abstract

The article describes modern trends in the development of human capital. The principles that should be included in the development of human capital in the conditions of digitalization are argued; the principles of progressiveness, complexity, adaptability, perspective, proactivity and economy are chosen. It was determined that the key principle is proactivity, which gives an advantage in preparation for changes caused by digital transformations, quick adaptation, acquisition of new abilities and digital skills. the methodological toolkit for the analysis and development of the human capital of industrial enterprises, which involves its evaluation in terms of value, analysis of the impact of human capital on economic indicators, cause-and-effect analysis of the conditions and results of the use of human capital, verification of digital competences of employees in digitalization strategies, forecasting of economic effects for the enterprise, is substantiated under the influence of changes in human capital based on digitalization.

Keywords: human resources, digitalization, human resources development, digital economics, economic changes

Introduction. For quite a long time, a person was considered only an expendable factor in production, and investments in education were considered unproductive. However, the transition to industrialization and the scientific and technological revolution of 1950-1960 inevitably changed the attitude to human capital and education, which, in turn, became the impetus for the emergence of the theory of human capital [1]. The consequences of the revolution caused global transformations in the world, in particular, the role of man, his education, previously acquired experience and professional qualifications became even more significant in the economy.

The active introduction of digital technologies in the 21st century began to change not only economic processes, but also all spheres of human life, as a result of which it led to a change in work, namely, an increase in the role of intellectual and creative work. The nature of employment has also changed (it became possible to work remotely), the requirements for the level and quality of education, as well as professional qualifications, have increased even more.

The concept of "human capital" has also undergone significant changes over the past centuries and is constantly supplemented with new characteristics, transforming from an industrial system to an informational and virtual one. Given the rapid development of the Internet, digital technologies, and artificial intelligence over the past ten years, new conditions for doing

business are being created, as well as the need for human capital development in digitalization conditions. Freelancing, outsourcing, gig -economy, management of contingent personnel, and robotics are just a few of the latest terms directly related to the development of human capital.

Having considered the main characteristics of human capital, the interpretation of the concept of "human capital" in the conditions of digitalization of the economy was proposed [2].

Human capital is a productive and rapidly adaptable to social, and economic changes and digital transformations resource of the economic system with immanent properties, formed thanks to the accumulation of experience, knowledge, competencies, and abilities, expressed in added value.

The digital transformation (digitalization) of all spheres of the economy undoubtedly calls for the creation of a new concept of human capital development, which would be relevant in the current environment, which is constantly transforming. The concept of "human capital", which appeared during the period of industrialization and with the transition to new stages of the development of society, acquired new features, and for now, needs to outline its characteristics in the conditions of digitalization of the economy.

Main part. With the development of digitalization, productive characteristics are undergoing greater changes, and if we take into account the aspect of the adaptive environment, then human capital is formed

based on new meaningful characteristics due to the digitalization of the economy from the standpoint of employees and employers (Figure 1).

Ability to be flexible and adapt to societal demands. For employees today, this meaningful component is key, as adapting to new trends enables the employee to be competitive in the labor market.

Ability to learn and constantly improve qualifications. If a person does not learn throughout his life, he is stuck in the past, the digital divide widens, while job offers decrease.

Ability to master a new profession. This component concerns changes like work and the introduction of technologies, along with which professions are changing. Yes, the once prestigious profession of a computer adjuster has disappeared with the advent of new technologies, and instead, employers need masters of repairing computers and various equipment, system administrators, and all kinds of engineers. If a person does not learn a new profession, another qualified worker can take his place.

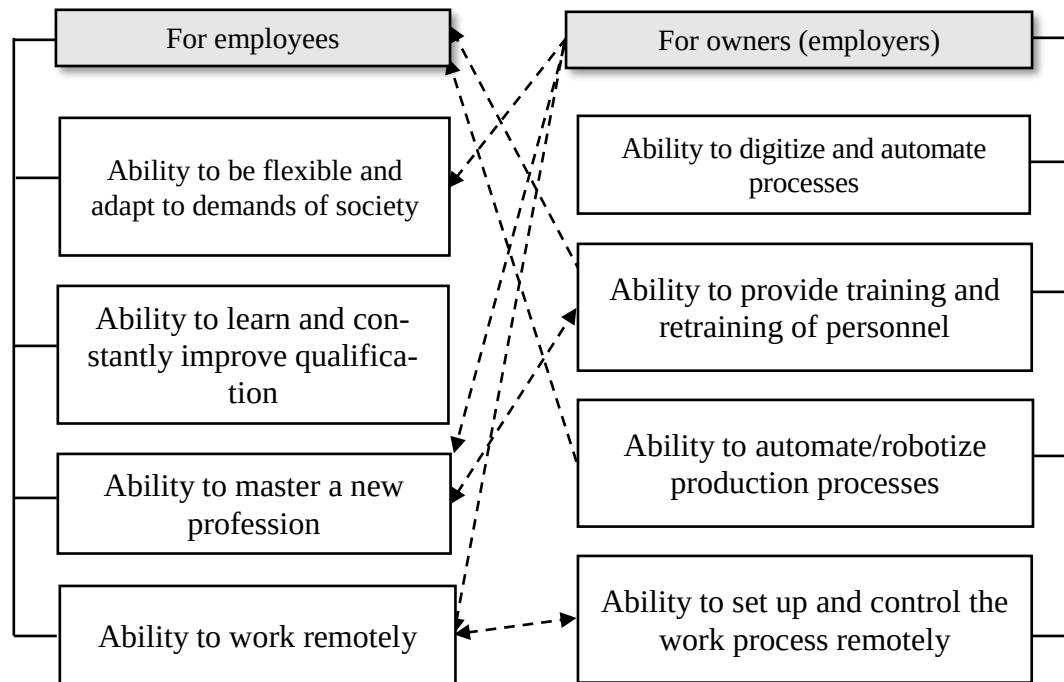


Figure 1. – Meaningful productive characteristics of human capital under digitalization of the economy from the standpoint of employees and owners (employers) (formed by the authors)

Ability to work remotely. This component has a proactive nature, as the transition of most processes to the online format is predicted.

The ability to set up and control the work process remotely correlates with the previous component, as the employer or company owner needs to set up processes so that in the future it is possible to manage production and business processes without leaving home or even being in another country.

The ability to digitize and automate processes characterizes the owner as a progressive leader who understands global trends and strives to develop his own business under the requirements of today's society, to form an efficient production that can compete on domestic and international markets.

The ability to provide training and retraining of personnel implies a correlation between the increase in the level of knowledge of human capital and the deepening of digitalization, and in the future and virtualization of processes, since thanks to employees, modernization of production can be made.

Ability to automate/robotize production processes. The implementation of this component will require qualified personnel, attracting investment in re-equipment, and motivating all participants in the process to modernize and improve working conditions to

increase labor productivity and receive acceptable incomes.

The development of human capital should be based on somewhat traditional principles, but with the transformation of economic processes and the environment based on digitalization, the approaches that are embedded in their observance are changing.

So, for example, *the principle of progressiveness* can be defined in a new way. It is necessary not only to follow trends and follow the example of developed countries but also to build our scenarios that would be unique and take into account the opportunities and the level of development of digital skills of human capital. Certain industrial enterprises have experience in the digitalization of processes, for example, in the administration or selection of employees, while enterprises in the IT sphere have long been reformatted, they only need to adjust and finalize the mechanism. Certain enterprises have not yet started the digitalization process. Human capital must be able to continuously learn and develop their skills to meet the demands of the labor market. New skills and competencies are becoming essential for success at work as digital technologies are constantly evolving. The principle of progressiveness, based on the experience of digitalization of Ukrainian

and foreign companies, is aimed at helping in the training and development of human capital.

Regarding *the principle of comprehensiveness*, it is worth noting that attention should be paid not only to all factors that affect the development and activity of human capital but also to those factors that may appear in the future. That is, predict possible changes and be ready that these factors will also determine the further development of events, as well as determine which factors of production are directly influenced by human capital. So, for example, there is an opportunity to take into account the changes that may occur if the future vector of Ukraine's development is directed to virtualization. The principle of complexity also helps us understand that human capital is not just the sum of individual skills and knowledge, but a system that consists of different elements that interact with each other. Because digital technologies are not self-sufficient, but only tools that can be used to solve problems and achieve goals, comprehensive problem-solving requires human capital that can think critically and analyze.

The principle of proactivity should be considered the key among all principles. If it were not for the force majeure circumstances of 2020, society would not be ready for the transition to digital rails. This event was the first push that made it possible to realize the need to move most processes into the digital space. This gradual partial transfer of certain processes to a remote format using cloud technologies, platforms for video conferences, and other tools made it possible to continue work during the full-scale war. People have become more flexible and mobile, moving to less affected regions, not leaving their jobs, but moving into a digital environment. Analysis of prospects for the development of society and readiness for changes is a key characteristic of the principle of proactivity. In the context of human capital development, the principle of proactivity means the ability to learn new things, readiness for changes, constant search for new growth opportunities, and maintaining one's competitive position in the labor market. Proactive people, that is, those who not only adapt to the challenges of society but also analyze and prepare for possible further changes, have an advantage in today's digital environment.

The principle of adaptability or flexibility is a supplement to the principle of proactivity, because proactivity involves predicting possible changes in the future, while adaptability helps to adapt to changes, taking into account different situations and moving to a new concept of development as much as possible, both for an individual and for the enterprise as a whole. The ability to be flexible means to increase prospects and productivity, because it is precisely such human capital and an enterprise that is characterized by flexibility that can stand in a competitive and changing environment. People who cannot adapt to new realities become unemployed, and enterprises go bankrupt and disappear. That is, the principle of adaptability in the context of the development of human capital in the conditions of digitalization means the ability to adapt to new technologies to change one's skills and competencies under the needs of the labor market. For example, businesses can

adapt their operations to digital technologies by using cloud storage for data processing or automating their business operations.

The next principle, which is selected for our concept, is *the principle of economy*, which involves the minimization of costs for production processes. This principle in the concept of digitization can be applied through the implementation of digital competence strategies since the digitization of document flow and communications can simplify the relationship between departments, increase awareness, and automate decision-making. The principle of economy means that it is necessary to use the minimum amount of resources to achieve the maximum result, and in the context of the development of human capital in the conditions of digitalization use digital technologies to train and upskill people faster, with lower costs and maximum efficiency.

Another principle that is worth paying attention to is *the perspective principle*, which will foresee not only changes in society that must be predicted in the future but also take into account the prospects of the organization itself and human capital in new realities. Digitization will transition to virtualization, new aspects of development will begin to appear, for which you must be ready and which will bring new perspectives both for employees and for the enterprise as a whole.

The development of human capital should be accompanied by a methodological toolkit that will provide both an analysis of the level of development and determine the necessary digital competencies for the implementation and implementation of its development strategies [3].

First of all, it is necessary to assess the human capital of the enterprise in terms of value. There are different methodical approaches to evaluating human capital. For example, for its assessment of a separate enterprise, it is suggested to apply the following indicators for several years: net profit of the enterprise; the average monthly salary of one employee in US dollars; the number of innovative developments; the rate of turnover of highly qualified personnel; professional development of employees; the number of employees with higher education [4].

A cost approach is used to determine the value of human capital based on the following methods [5]:

- the method of determining initial costs involves calculating costs for the formation and reproduction of human capital and further discounting these costs. It is the basis for determining the initial (accounting) value of human capital;

- method of accounting for restoration (reproduction) costs. The cost of restoration is equal to the cost necessary to create an exact copy of the given intangible asset. The essence of this method is to assess the subjective value of an employee for a specific company. The estimate can be obtained as a result of modeling the situation of a sudden dismissal of an employee and calculating the amount of costs for the formation of knowledge and skills of a new employee, as well as the unearned profit during this formation;

— replacement cost accounting method. The costs of replacing an employee include the cost of selection, hiring and training of the replaced workforce, which is formed from the following group of costs [5].

From our point of view, for the effective use of human capital at enterprises, it is worth finding out the value of human capital for the enterprise, which will provide an opportunity to determine how much the enterprise is equipped with, and what share such capital makes up in the total cost. For this purpose, you can use the AK model (R. Lucas) [6], what takes into account the value of human capital in terms of value. Applying appropriate procedures to the model allows you to determine the value of human capital through the equation of net income from the sale of products, depending on the technological parameter, physical capital (fixed assets), the number of employees, and the level of human capital possessed by a typical representative of the workforce.

The next methodical metric for use in the development of human capital can be the analysis of the influence of human capital on the economic indicators of the enterprise [7]. Knowing the value of human capital, it is advisable to determine whether it has an impact on the resulting indicators of the enterprise, such as labor productivity, gross profit per person, and income from the use of the labor of one employee, which can be carried out with the help of correlation analysis. This will allow us to determine the importance of human capital in the efficiency of the production and economic activity of the enterprise.

Investing in the development of human capital in the context of digitalization requires finding out whether, indeed, the conditions created for development provide the expected results from the use of such capital after development measures [8]. For this purpose, it is advisable to apply a cause-and-effect analysis of the conditions and results of the use of human capital. To do this, you can use *taxonomic analysis*, which allows you to determine cause-and-effect relationships between indicators of financial and economic activity and the development of human capital in the conditions of digitalization. As indicators of the conditions for the effectiveness of the development of human capital, the following can be used: the share of wages in net income, average monthly wages, capital resources, the level of investment per person, and the general level of staff turnover. It is advisable to evaluate the conditions of the effectiveness of the use of human capital by such indicators as labor productivity, gross profit per person, added value of human capital, the ratio of the growth rate of gross profit and the growth rate of the cost price, as well as the ratio of the growth rate of labor productivity and the growth rate of the wage fund. Based on collapsing parameters and taxonomic analysis, it is possible to establish indices of the conditions for ensuring the effectiveness of human capital and the effectiveness of the use of human capital. Their comparison will make it possible to determine the type of economic behavior of enterprises and the necessary economic actions to improve the digital competencies of employees.

The next methodical tool is the verification of digital competencies of human capital for digitization strategies [9]. Such a verification using Saati's method [10] and the index of digital competence allows you to determine the necessary set of digital skills for each of the digitalization strategies, which will optimize their implementation and ensure the effectiveness of implementation.

of digitization strategies through the use of human capital developed based on digitization requires economic and mathematical modeling to determine the predictive data of the feasibility of investing in several measures, including increasing the armed forces of employees with digital technologies and software, investing in training and improving the qualifications of employees, increasing employee wages with a high level of digital competencies. Forecasting economic effects for the enterprise under the influence of changes in human capital based on digitalization will allow the establishment of the expediency of implemented economic and organizational measures.

Conclusions. In general, the study of the concept of "human capital" made it possible to distinguish its economic meaning and key features that were characteristic of different periods from the period of industrialization, informatization to modern times, where society acquires signs of digitization and partial virtualization. In the studies of scientists, the content of the concept of human capital did not change significantly, acquiring new features with the transition to new stages of development, but a modern definition of human capital, which would include elements of digitalization of the economy, was not formed. Undoubtedly, the list of characteristics that human capital must possess is becoming more complex and taking on new forms, which include the ability to master digital competencies, be adaptable, and be able to work remotely. The principles and methods of evaluating the development of human capital described in the article provide an opportunity to comprehensively approach the change of the development strategy of enterprises, since, by verifying the presence of digital competencies among employees, there is an opportunity to increase the efficiency and competitiveness of the enterprise.

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MEDICAL SCIENCES

POSITIVE AND NEGATIVE QUALITIES OF SILICONE IMPRESSION MATERIALS

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Abstract

Today we finally have a previously unknown problem. Problem of choice. There are so many dental materials that many have long been confused by the diversity of the offer and cannot understand what is better, why it is better and how to use it. Even experienced doctors often make basic mistakes, while beginners sometimes don't even know how to use this or that impression material.

Keywords: alginate materials, A-silicones and C-silicones.

Modern dental materials science continues to research and present new impression materials with the necessary characteristics and certain qualities, without which it is impossible to imagine the manufacture of any orthopedic structure. After determining the treatment plan and choosing a design, the orthopedic dentist sets himself the task of selecting an impression material to achieve good results [2, 6]. A correctly obtained impression should accurately reflect all the relief features of the surface of soft tissues, opposing and adjacent teeth and the supporting tooth.

When choosing an impression material, it is necessary to take into account such factors as the design features of the future prosthesis, the pliability of the oral mucosa, as well as the condition of the gingival sulcus [4, 5, 7]. Today, dental impression materials face a significant number of requirements: accurate negative representation of the anatomical shape of the teeth and the relief of the soft tissues of the mucous membrane; hydrophilicity, biocompatibility, ease of use, dimensional stability [3]. E.G. Agadzhanian believes that the classification of impression materials by I.M. Oxman, which is the most popular, is not currently used. Russian clinics in most cases use polyesters, alginate materials, A-silicones and C-silicones [1].

The purpose of the study is to study the properties of class A and C silicones according to literature sources. Conduct a survey of dentists to study the prevalence of use of materials. Research objectives. Find out the positive and negative properties of A and C silicone materials.

Material and methods.

During the formation of the research work, we studied domestic and some foreign literature. A survey of 20 dental orthopedic doctors in practical healthcare was carried out. The following questions were asked: 1. Preference in use between A-silicone and C-silicone. 2. Which silicone material is more convenient for you to use? 3. Which silicone material, in your experience,

gives a more accurate impression? 4. Have there been any cases of allergic reactions when using these materials? We also carried out a practical study - taking impressions using several representatives of different groups of silicones: A- and C-silicones. Study the properties of each class. Results. As a result of a survey of 20 orthopedic dentists, it was found that only 35% of respondents prefer to use silicone material of group "C" in their work, the remaining 65% of doctors prefer silicone impression materials of class "A". Based on the results of a practical study, as well as taking into account reviews of orthopedic dentists and literature data, the following positive properties of silicone impression materials of group "A" can be noted: the components of these materials are easily mixed due to the homogeneity of the main and catalytic pastes; do not have an unpleasant odor or taste; accurately reproduce the relief of the prosthetic bed, are hypoallergenic, do not have a toxic effect, and also have high hydrophilicity. The main negative properties of materials in this group include, first of all, high cost compared to silicone materials of group "C", as well as the inability to knead the material in latex gloves due to a violation of the polymerization reaction of the print. Silicone materials of class "C" are inferior in their properties to materials of class "A". The main positive properties of C-silicones include: relatively low cost, low shrinkage, good elasticity and at the same time strength of the base and corrective masses, as well as the possibility of disinfecting the impression. Negative properties of C-silicones: insufficient adhesion to the impression tray, hygroscopicity (sensitivity to moisture), low hydrophilicity, lack of automatic mixing of material components, excessive rigidity of the base mass. In addition, the literature describes cases of toxic effects of the mass on the human body. In addition, higher accuracy of plaster models was obtained using impressions made from silicone material of group "A".

Conclusion. From our practical research, it became clear that for the manufacture of microprostheses, as well as prostheses that require an ideal marginal fit, it is necessary to use materials that give a lower relative error of plaster models - group A silicones. In the manufacture of larger dentures, impression materials can be used, the relative the error of which is greater, for example C-silicones. Conclusion. Based on the studied material, a survey of orthopedic dentists, and practical research, we can conclude that the most important and important positive property of group "A" silicones is hydrophilicity, which makes it possible to obtain a better and more accurate impression, which is necessary for the manufacture of denture structures. A negative property is its rather high price compared to other impression materials. The main positive property of group "C" silicones is that they are inexpensive for the traditional two-stage technique and are accurate in reproducing small details. A negative property is low hydrophilicity. Both during the survey and during the practical study, no cases of allergic reactions to silicones of groups "A" and "C" were identified; cases of toxic effects were described only in the literature - to silicone "C".

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ANALYSIS OF THE QUALITY OF REMOVABLE DENTURES ON IMPLANTS

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Restoring chewing function with various types of prostheses in case of partial loss of teeth remains an important task in orthopedic dentistry. The presence of defects in the dental arch leads to a violation of the integrity of the dentition and the appearance of morphofunctional changes in the dentoalveolar system, occurring first near the defect and then spreading to the entire dentition. This leads to vertical movement and inclination of teeth that limit the defect, devoid of antagonists, as well as overload of the remaining teeth, disruption of occlusion, and changes in the mandibular joint[1]

Keywords: complete absence of teeth; dental implantation; the quality of life; removable prosthetics.

Changed conditions for the functioning of teeth cause a restructuring of metabolic processes, which depend on the force of the chewing load. With partial adentia, tissue hemodynamics are disrupted in the area of the dentition defect, the intensity of blood circulation decreases, and vasoconstriction of blood vessels is observed. New opportunities have opened up thanks to the introduction into clinical practice of implantation of artificial supports for dentures, expanding the conditions for removable dentures. Modern dental implantology with subsequent prosthetics has proven itself as an effective method for restoring defects in the dentition[2]. Removable dentures supported by implants, unlike other types of orthopedic treatment, provide a more complete restoration of the chewing function of the dental system and rapid adaptation to them[3]. However, despite the successes of implantology, reducing the number of complications and increasing the life of prosthetic structures using intraosseous implants remains an urgent problem. Literature data devoted to the study of the role of functional load in prosthetics using intraosseous implants allow us to conclude that, despite the large number of clinical and experimental works, the physiological direction in the study of the state of the dentoalveolar system has not been sufficiently developed. To solve the problem of preventing complications in implantology using orthopedic methods, a comprehensive study of a number of issues related to metabolic processes in the tissues of the area of the dentition defect is required. In this regard, the study of dosed loads, an objective assessment of the functional state of supporting tissues before and after treatment is the basis for the development of therapeutic and preventive measures to prevent the development of pathological changes in the tissues surrounding natural teeth and intraosseous implants. The majority of patients who need to restore the integrity of their dentition have formed a negative opinion about prosthetics with removable types of dentures, due to problems of insufficient resto-

ration of chewing function and aesthetics, and unreliable fixation of dentures [3]. The majority of patients with partial loss of teeth (86.1%) prefer fixed dentures, which are more functional, durable, and aesthetic. It is known that the effectiveness of orthopedic treatment methods with bridges is significantly higher than with removable structures [8,9]. In case of untimely prosthetics in patients with partial loss of teeth, the body's adaptive capabilities are disrupted, which leads to the emergence of pathological processes in all components of the dental system, preventing adaptation to dentures and disrupting the harmony of interaction of all its elements [1–3,5,6]. Currently, there are various methods of fixing removable dentures used in the treatment of patients with partial loss of teeth. In recent years, interest in prostheses that do not have clasps in their design has increased significantly. Such fixation methods include beam fixation of prostheses, using magnetic elements, using telescopic systems and, finally, locking fixation methods [1,3,6,7]. The method of using prostheses with locking fixation is not a simple repetition of prosthetics with removable plate or clasp dentures. There are special algorithms for planning and manufacturing prostheses with locking fixation systems, ignorance of which can lead to serious errors and thereby discredit the method as a whole [10]. Of considerable importance when choosing a method of fixing a removable denture is the possibility of restoration, repairing it in the event of the loss of one or more supporting teeth, as well as the possibility of replacing or activating retaining elements. Known methods of fixing removable dentures are not equivalent according to the above criteria [3,9,10]. Removable dentures with a locking fixation system splint the abutment teeth well and redistribute the chewing load to all supporting tissues of the prosthetic bed [2,8,9]. Good fixation, stabilization and high functional efficiency have increased interest in these structures in recent years [4,5,7]. The emergence of modern, durable alloys, indifferent to the tissues of the prosthetic bed, high-precision casting and milling

methods have expanded the technological capabilities of their manufacture. Insufficient theoretically justified use of removable dentures with locking fixation, calculated on the basis of empirical data, often leads to unsatisfactory results of prosthetics [2,3]. When choosing an orthopedic design that optimally distributes the load between the existing supporting elements, a preliminary theoretical justification for the choice is of great importance [1,4]. This allows us to predict the successful functioning of the entire system and avoid complications [7,8]. There are publications devoted to locking and telescopic fixation of removable dentures [5,6], but they, as a rule, discuss to a greater extent the technological aspects of the issue or state certain negative clinical manifestations without touching on the mechanism of their origin. An analysis of domestic and foreign literature has shown that, despite significant progress, the issue of orthopedic treatment of patients with dentition defects using removable dentures with locking fixation has not been sufficiently studied and requires further consideration. Purpose of the study: Clinical and biomechanical assessment of the effectiveness of removable prosthetics in dental prosthetics using implants.

Material and methods

A comprehensive examination and treatment of 38 patients with limited dentition defects was carried out using intraosseous implants with locking fixation (attachments). There were 10 men (26.3%), 28 women (73.7%), the age of the patients was from 21 to 60 years, without concomitant diseases. At the prosthetic stage, 248 implants were used in patients of the study group, including 213 screw (91.0%), 29 short porous (7.9%) and 4 flat implants (1.1%). The average number of implants per patient in the study group was 4.0. It was these implants that were subsequently observed to evaluate the clinical effectiveness of various types of prosthetics in patients with complete absence of teeth (PED). In 12 (16.4%) of the 73 patients in the study group, implantological treatment using bridges and removable dentures was performed on two completely edentulous jaws, so dental prosthetics supported by implants was carried out on a total of 25 edentulous jaws (6 upper and 19 lower jaws). In patients of the 1st and 2nd control groups, the implants were considered sound and were involved in the process of prosthetics with single artificial crowns. At the time of admission to the orthopedic stage of treatment, the average value of objective stability of the implants was -3.2 ± 2.4 in patients of the study group and -3.4 ± 2.4 in the control group.

Results

Analysis of the results of treatment of patients 1 year after completion of prosthetics showed that there were no rejections of any of the implants included in the prosthetics in patients of the study group. At the same time, in patients in the control group, rejection of the 1st implant, which served as a support for a single crown, was revealed. Total implant preservation index: the clinical effectiveness of prosthetics in patients of the study group was 100%, and the same indicators in the control group were 98.9%. Thus, there are no significant differences in treatment results in the study and control groups, but, in any case, with bridge and removable prosthetics supported by implants in patients with

POP, the number of favorable outcomes is no less than with implantological treatment with single crowns. When examining the condition of the gums 1 year after completion of prosthetics, no pronounced inflammation was found in any patient of the compared groups. At the same time, minor signs of inflammation in the form of mild hyperemia and bleeding during probing were observed in the area of 35 implants in patients in the study group and in 7 of the remaining implants in the control group. The difference in treatment results on this basis is not statistically significant. Gum recession of 1 mm or less 1 year after completion of prosthetics was found in the area of 16 (4.3%) implants in patients of the study group and in the area of 6 (6.9%) implants in the control group. Consequently, gum recession in patients in the study group occurs significantly less frequently than in patients in the control group. There was no gingival recession of more than 1 mm. An assessment of the condition of the bone tissue surrounding the implant showed that at the time of fixation of the prostheses in the oral cavity in the area of 2 implants at the level of the apical and middle third of the intraosseous part, foci of resorption with a diameter of 2 to 5 mm with uneven and unclear contours appeared, but upon study bone tissue 1 year after completion of the prosthetics, these phenomena disappeared, and an organotypical bone pattern of normal density was observed. The loss of the marginal bone level 1 year after fixation of the dentures in the oral cavity in patients of both the study and control groups turned out to be identical and averaged 0.3 ± 0.2 mm. The levels of satisfaction with the prosthesis and the quality of life after prosthetics, determined using a questionnaire, 1 year after its completion, were determined not only in patients with dental implants, but also in patients in the control group with complete removable laminar dentures of a conventional design. Satisfaction with the prosthesis of patients in the study group was 4.2 ± 0.4 points, in patients in the control group with implants - 4.5 ± 0.5 points, in patients in the control group with conventional removable dentures - 2.3 ± 0.6 points. The difference in the degree of satisfaction with the prosthesis in patients of the study and control groups with implants is not statistically significant, at the same time, satisfaction with the results of bridge and removable prosthetics supported by implants in patients with POP is significantly higher than with prosthetics with conventional complete removable dentures.

Conclusion.

Thus, the assessment of the quality of life performed by patients 1 year after fixation of prostheses in the oral cavity showed the following results: out of a possible 70 points, patients in the study group had 62.7 ± 5.2 points, patients in the control group with implants - 65.7 ± 3.7 points, in patients of the control group with conventional removable dentures - 47.8 ± 6.6 points.

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PEDAGOGICAL SCIENCES

FORMATIVE ASSESSMENT ON ENGLISH LANGUAGE LESSONS WITHIN PRIMARY EDUCATIONAL INSTITUTIONS

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Abstract

This article examines the role and impact of formative assessment in English language lessons within primary educational institutions. Formative assessment, characterized by its continuous and developmental nature, holds significant promise in fostering effective learning environments, particularly in the domain of language acquisition. Through a comprehensive review of literature and empirical evidence, this study elucidates the various strategies and methodologies employed in formative assessment practices tailored to English language instruction at the primary level. Furthermore, it explores the benefits of integrating formative assessment techniques, such as peer assessment, self-assessment, and constructive feedback, into pedagogical approaches. The article also addresses the challenges and considerations in implementing formative assessment in primary English language classrooms, including teacher readiness, assessment design, and cultural factors. By synthesizing theoretical frameworks with practical insights, this research contributes to a nuanced understanding of how formative assessment can optimize learning outcomes and language proficiency among primary school learners.

Keywords: formative assessment, primary education, learning outcomes, pedagogical approaches, peer assessment, self-assessment, feedback, primary school learners, language proficiency

Teaching students is the main goal of the educational system and requires methods of assessing students' knowledge and competencies. In this context, the importance of formative assessment cannot be overestimated. The concept of "formative assessment" arose in American pedagogy back in the 60s of the 20th century, so the methods of conducting formative assessment are very diverse. Formative assessment is assessment during learning and "for learning". It is "formative" because, unlike the final one, it aims to shape (or format) the educational process taking into account the educational needs of each student for the more effective formation of the necessary knowledge, skills and attitudes. Formative assessment is sometimes called assessment for learning, and it usually involves some form of diagnostic testing that allows a teacher to identify gaps in student learning and then target a student with those gaps by adjusting the instructional planning sequence to address those gaps.

The following scientists contributed to the development of formative assessment ideas: O. Kmit, A. Panayiotis, M. James, D. Chróinín, C. Cosgrave, etc. O. Kmyt in the method of formative assessment in primary school singles out the following components - the first component involves the definition of objective and understandable for students learning goals for learning a foreign language in each lesson, where the set goals are the desired learning outcomes and provide a clear idea of the need for mastery language, speech, linguistic and educational-strategic competences; the second component of the method of formative assessment is effective feedback, which acts in two directions: on a teacher and on a student, and provides a teacher with

information about the level of success of the students. The third component of the method of formative assessment in foreign language primary education is ensuring the active participation of students in the process of mastering a foreign language. The fourth component involves the development and discussion of criteria with the involvement of students [3].

A. Panayiotis and M. James, considering the effectiveness of formative assessment, argue that most teachers see advantages in formative assessment that can benefit both students and teachers, but the latter cannot accurately describe the practical experience of formative assessment. In general, formative assessment is considered by teachers as reporting to parents, external motivation of students, organization of group learning, posing many other questions during learning, etc. [7].

It should be noted that in educational activities, teachers pay attention to the coverage of the planned curriculum, and not to the students' learning itself, but the main goal of education is to promote understanding, not short-term memorization. That is why a modern teacher should use in his classes methods that involve students using their knowledge, connecting them with the real context, and pay attention to formative assessment in the context of reforming the Ukrainian primary school.

According to the State Standard of Primary Education of Ukraine, obtaining data, analyzing them, and formulating judgments about the results of students' learning are carried out in the process of formative assessment, the purpose of which is to track the personal

development of students and the acquisition of educational experience; final evaluation, the purpose of which is to correlate the educational achievements of students with the mandatory/expected learning outcomes determined by the State Standard or the curriculum. It must be taken into account that formative assessment begins from the first days of schooling and continues continuously. For the effectiveness of formative assessment, it is recommended to follow the teacher's activity algorithm during its organization:

1. formulation of objective and understandable educational goals for students;
2. definition of assessment criteria together with students;
3. forming the subject position of students in the assessment process;
4. creation of conditions for the formation of students' ability to analyze their own educational activity (reflection);
5. adjustment of approaches to learning together with the students, taking into account the results of the assessment [6].

Speaking about formative assessment in primary school according to the requirements of the New Ukrainian School, it should be noted that the use of the latter in the classroom means that the teacher monitors the students' learning, providing regular and timely feedback about what the students did well and what they need to improve. Formative assessment can take many forms, from informal tests to verbal feedback on work. In order to be effective in the classroom, formative assessment must occur every day during teaching and learning. It is also conducted to help teachers decide how to further develop students' understanding of the material taught.

Formative assessment can serve a variety of aim, including highlighting gaps in student learning that require further clarification; identification of strengths and weaknesses of an individual student in comparison with others; measurement of the amount of knowledge that students have received; providing a system for comparing the educational achievements of students in a class, district and country as a whole. Within the stated goals, four types of formative assessment practices are distinguished:

1. Clarifying learning (what teachers want students know and be able to do) is to explain to students the motivation for their learning, help them evaluate themselves in comparison with others and determine where they are on the learning ladder.
2. Gathering evidence involves the creation of effective discussions and questions, the organization of action locations in the lesson, etc., in order to meet the educational needs of students at the moment and promote students' thinking.
3. Providing feedback (how students know what to work on next) involves working with students to obtain information needed to better understand learning problems and their solutions.
4. Activation of students' motivation to study (in what way can we encourage students to study and help their peers). In the process of observation, it was found that when students were involved in monitoring their

own progress, they were "more autonomous and could accurately predict their success." To help students develop an academic growth mindset, teachers can actively support them in finding learning strategies that work best for them by providing opportunities for self-evaluation, setting learning goals, and monitoring their own progress [5].

Formative assessment explores the benefits of integrating formative assessment techniques, such as peer assessment, self-assessment, and constructive feedback, into pedagogical approaches. By incorporating peer assessment, students actively engage in evaluating their peers' work, fostering a collaborative learning environment where they not only receive feedback but also develop critical thinking and analytical skills. Similarly, self-assessment encourages students to reflect on their own learning progress, strengths, and areas for improvement, empowering them to take ownership of their learning journey. Additionally, providing constructive feedback, both from teachers and peers, facilitates targeted interventions and helps students identify specific areas where they can enhance their language proficiency. This integration of formative assessment techniques not only enhances the quality of instruction but also promotes student-centered learning experiences that cater to individual needs and promote holistic development.

When considering methods of formative assessment, such methods 'What Well Well' (WWW) and 'Even better if' (EBI). This feedback involves students understanding what they have achieved to date and what they need to do next to make further progress in their learning. When using formative assessment methods, it is necessary to follow the following structure: setting the task, checking students' work, informing about instructions and teaching methods.

Examples of formative assessment in the classroom include:

- Analysis of a student's work - self-assessment, assessment of others or peer assessment;
- Strategic questioning (students are asked questions to assess their understanding of the material based on their answers);
- Three-part summary – students write three summaries in response to a topic to test their understanding of its content;
- Exchange in groups - students discuss the topic in pairs, and teachers record their discussions;
- Survey in the classroom - did everyone understand?
- One-minute reports - students briefly write down their answers, summarizing their key knowledge of the topic;
- Spontaneous quizzes and voting exercises;
- Mind maps – encourage students to summarize what they already know about the topic in a creative and visual way;
- Concluding paragraphs – short written exercises to understand how well the students understood the topic;
- Visual exercises – a teacher offers students to draw something or create a collage on the studied topic;

- "Questions and answers" exercises — encourage students to ask questions and observe their classmates' answers;

- Short presentations – a teacher asks students to make short presentations on the topic to show what they have learned during the study of the topic.

- Exit ticket – a teacher offers to answer questions at the end of the lesson, which are related to the topic or previously studied material.

Considering formative assessment in Ukrainian primary educational institutions, we note that the latter should take place in every foreign language lesson. The experience of the world's leading educational institutions, in particular, Great Britain, will be useful in the implementation of formative assessment. Thus, in Ireland the Education Act (1998) and the Irish Primary School Curriculum (1999) define assessment as an integral part of the teaching and learning process, which can help determine what and how a child learns. In the Irish context, a combination of formative and summative assessment using a wide range of assessment strategies is recommended at primary level with specific guidance on the use of teacher observations, teacher-designed tasks and physical education curriculum profiles [2, p.220].

Cockenzie Primary School (UK) has implemented the following formative assessment strategies to improve student learning. Increased waiting time encourages all children to respond. Talking Partners is an opportunity to have a short discussion with others and learn new ideas. Asking open-ended questions encourage children to think, and not just answer "yes" or "no"; Feedback - focusing on a specific learning intention at the appropriate time, self/peer assessment in which children take responsibility for reporting their work to a teacher/group. Colored marks for growth indicate success and a problem that needs to be worked on. 'Traffic light' strategy when children show how well they have understood the task (can be used to find out how well a child thinks they have completed the task).

At Blue Drive Primary School (England), formative assessment is an integral part of the teaching and learning cycle and is an important part of effective educational practice in the classroom. Formative, summative and diagnostic assessment policies for speaking, reading and writing are interrelated as reading comprehension can be improved in both speaking and writing. Every year, the school conducts a planned three-year cycle of professional development of teachers for their progress in accordance with the requirements of the national curriculum and modernity [1].

We can conclude that formative assessment has many advantages in teaching primary students in English classes and helps them accurately understand the level at which they are working. In addition, formative assessment allows putting their level of understanding in the context of what they have learned, reduces learning gaps, gives children a clear idea of how they are

progressing and what they need to do to improve their learning outcomes. Formative assessment sets students clear educational goals and increases their involvement in learning; helps provide more targeted and personalized feedback to students, etc. As a perspective, we see the appropriate use of the above-mentioned methods of formative assessment in English language classes, which will help teachers to track children's progress in an interesting and less formal way, to test them both in the classroom and in individual assessment of students. At the same time, a teacher has the opportunity to create his own approach that will allow children make a certain contribution to learning, providing them with useful and consistent feedback. Among the advantages of formative assessment, we can highlight teachers' understanding of students' material acquisition and the ability to adjust teaching, when they can use the results of formative assessment to improve their own educational achievements and progress, adjust learning under the guidance of teachers, increase motivation, etc.

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PHILOSOPHICAL SCIENCES

INTERNAL REGULARITIES OF FUNCTIONING AND DEVELOPMENT OF THE INFOCOMMUNICATION TECHNOLOGY SYSTEM

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Abstract

The article analyses the internal regularities of functioning and development of the system of info-communication technologies at the present stage of human civilisation development. The significance of this system as a naturally occurring element in the structure of the noosphere is revealed. The importance of these technologies as the basis of the global cognition system that turns the Earth into a subject of the Universe and allows each person to participate in the global thought process is shown.

Keywords: noosphere, civilization, information society, infocommunication technologies, global cognition system.

The concept used to define the current stage of human civilisation development - 'information society' - quite accurately and correctly, in our opinion, reveals the essential properties of the current stage of human civilisation development. It is knowledge and information in the broad sense that increasingly determine the degree of humanity's impact on its natural environment, ensure its transcendence beyond the earthly boundaries and at the same time serve as the most important factor in solving problems arising in the process of functioning of the global social organism.

It is obvious that the system of information and communication technologies as the core of the information society includes various structural and functional components (technical devices, software, a corresponding set of services, etc.). However, its most important and primary goal is to ensure information exchange. The degree of implementation of this goal determines the overall importance of the ICT system in the processes of human civilisation. Besides, the development of other elements of this system also depends on the efficiency of this function. Moreover, as the info-communication environment is formed, its essential properties become more and more vivid; the components ensuring their realisation are the most dynamic. They themselves ensure accelerated development of its other elements.

The study of the sphere of information and communication technologies as a necessary component and, at the same time, an important stage in the development of the noosphere allows us to trace its inherent internal regularities of functioning quite clearly.

The ICT sphere understood in this context, should be regarded as a global system in essence and form of existence. Accordingly, its main essential properties also begin to manifest themselves in due measure when it reaches the planetary scale in its development, covers, as a full-fledged shell, the entire Earth, providing

a qualitatively new level of communications. Accordingly, until the sector of info-communication technologies has not passed the necessary stages of development, has not formed sufficiently, its essential characteristics do not manifest themselves in an obvious form. Until they reach the global level within the planet, they are present in a hidden, undeveloped state; they are rather virtual than real.

In this context, the formation and development of the system of info-communication technologies should be considered as a natural stage in the development of the noosphere. The term 'noosphere' was introduced into scientific circulation by Teilhard de Chardin [1, p. 27]. However, the holistic theory of noosphere as a special shell of the Earth was developed in the works of V.I. Vernadsky [2, p. 15]. The noosphere, understood by V.I. Vernadsky as a 'reasonable' shell of the Earth, assumes and, at the same time, should provide not only a potential but also a real opportunity for everyone to participate in the planetary thought process [3, p. 72]. This characteristic turns out to be more important than a disparate set of individual, even if brilliant people. Therefore, the essential properties that must be realised with necessity in the process of functioning of such a global system are fundamentally important.

Firstly, by definition, the functioning of the noosphere is directly and directly connected with the thinking activity of both an individual person and mankind as a whole. The very products of human thought, taken in 'pure' form, should increasingly manifest their value not only in figurative, but also in the direct sense. Knowledge itself must acquire market value.

Secondly, planetary communication systems, which ensure the dynamic unity of the functioning thought of mankind, must develop at a faster pace. A constant increase in the volume of transmitted information is a necessary condition for achieving a qualita-

tively new level of humanity's awareness of the problems it faces and finding effective ways and means of solving them.

Thirdly, each subject of the global thought process should have the possibility of permanent access to the above-mentioned global system, free from spatial and temporal limitations. The inclusion of as many people as possible in the universal planetary flow of thought is ultimately more important for the sustainable progressive development of mankind than the task of enhancing the intellectual abilities of individuals by technical means.

In other words, the systemic characteristics of the sphere of info-communication technologies [4, p. 257] are in the foreground, rather than the means that strengthen its individual elements.

Let us try to consider the realisation of these essential properties of the sphere of info-communication technologies in the historical process of its origin and development.

The very system of modern information and communication technologies gradually grows out of the 'traditional' technical component of the economic and scientific spheres of society, the formation of which began with the industrial revolution. And initially it does not seem to differ from the structures already existing in the above-mentioned spheres. However, this system potentially contains qualitative differences, which become more and more apparent over time.

Initially these processes start with the appearance of large computers localised in special computing centres. The main value here falls on the technical components of electronic-computer complexes. That is, the most valuable initially is the technical component, in which the achievements of science of this period are realised and human knowledge is 'defined'. But over time, the proportion between 'object-realised' and 'pure' knowledge begins to change in favour of the latter. The intellectual component begins to directly and directly manifest its own value, to acquire an obvious, clearly fixed, rather than indirect price on the market. Already the initial spread of personal computers demonstrates a previously unknown and psychologically unfamiliar economic situation. The cost of acquiring licensed software turns out to be, although not the largest, a very visible cost element; its cost starts at ten per cent of the cost of the computer itself. This very fact initially creates certain socio-psychological problems, as it is not very clear what exactly needs to be paid for and how to fix this object of purchase and sale.

However, rather quickly it turns out that the effectiveness of the introduction of personal computers does not give the expected effect, and is very far from the predictions of science-fiction and futurologists. In the 80s in the USA it was directly noted that personal computers are used mainly as electronic typewriters, and the possibilities inherent in them are irrelevant for the majority of users. That is, the appearance of a large number of terminal devices that strengthen the person possessing them did not bring the expected effect precisely because they remained disparate, not permanently connected with each other. It was required to turn them into

elements of a single system, i.e. to give each of them a certain global characteristic.

This process happens quite quickly in the scales of history: local networks and the global network - the Internet - appear. It is the appearance of the latter that completes this stage of development of the info-communication technologies system, when the latter reaches the global level of development, i.e. turns into a truly worldwide network of information exchange.

To reach this level, firstly, a completely new level of telecommunication means (both technical and software) was required, secondly, new software means and, thirdly, special services for their maintenance. It is these components of the ICT system that have gradually come to the fore as compared to the terminal devices.

Let us try to illustrate these processes in concrete figures. It should be noted that the cost characteristics of the components of the info-communication technologies sector can differ in value by one and a half to two times in different sources. (Some elements, such as the number of mobile phones and smartphones currently in use, cannot be accurately estimated at all). This is particularly evident in analyses of the current state of affairs in this area. Therefore, let us take the years 2009-2010 as an example, in the assessment of which there is a relative unity of views.

Thus, according to Gartner, the volume of the global services market was 3.4 trillion US dollars (some estimate it at 3.6 trillion US dollars). However, computers themselves, i.e. the main component of the ICT market in the second half of the 1990s, accounted for 353 billion US dollars, and the purchase of licensed software - 232 billion US dollars, i.e. the cost of purchased standard software was already 65.7% of the cost of computers, compared to 10% in the mid-90s.

However, the total cost of computers and the software required for them was significantly less than the cost of IT services. Consumer spending on the last component of the info-communication technologies sector, representing 'pure' human labour and 'pure' knowledge, was 40% higher and amounted to USD 821 billion. And about \$100 billion was spent on hardware support, while the rest was spent on ICT consulting, consumer-specific software development and support. And about one-third of IT services spending was on information services within companies.

But all of the above costs were less than what was required for such a component of the ICT system as telecommunications. Their cost amounted to 1.9 trillion USD, i.e. more than 55 per cent of all expenditures on the information and communication technology system in the world.

In other words, already about twenty years after the beginning of mass distribution of personal computers, their cost was only about 10 per cent of all info-communication expenditures. And the cost of basic software for them and IT services, i.e. 'pure' thinking products, exceeded the cost of computers three times.

Such a rapid development of the latter is obviously a reflection of the essential regularities of the information and communication technologies system functioning as a necessary component of the noosphere [5,

p. 378-379]. Human knowledge, human thought are the most dynamic of the known processes. Therefore, they should develop ahead of all other components of reality. And the inclusion of hundreds of millions and billions of living people in this process accelerates it many times.

However, in our opinion, there are also factors, purely socio-economic in nature, which cause such a rapid development of these components of the system of info-communication technologies.

First of all, it does not require large investments for job creation. In manufacturing industries, in machine building, the cost of fixed assets is many times higher than the cost of labour force; tens and hundreds of thousands of US dollars are required to create one job. And in the sphere of information and communication technologies the monthly salary of a programmer exceeds the cost of technical means necessary for his effective work. Moreover, these means can be used practically round the clock, which further reduces the required initial capital investments. And often such investments are not required at all, as the programmer uses his own computer.

Further, the very nature of work determines a rather high cost of the produced product, since the latter is quite unique [6, p. 39]. Therefore, this type of activity is highly profitable and provides a quick return on investment. Of course, it requires sufficiently educated and professionally trained people, but it does not require more time than in other areas of human activity.

An important factor is also, in our opinion, the absence of territorial restrictions in attracting the necessary employees. Info-communication technologies themselves ensure the formation, in fact, of a single world market of labour force of this profile. A person can perform the received task remotely; he/she does not need a specific workplace. As a result, both spatial and time constraints on attracting the necessary employees are eliminated, i.e. the importance of a person as the main productive force is fully manifested. In fact, the employer can use the world's resources, the world's mind, to create a product that is thought-provoking in nature in a local space.

Finally, it is necessary to note one more factor of economic efficiency of this particular component of the information and communication technologies system. The capitalisation of companies engaged in this sector of the economy depends to a very large extent on the information support of their activities, a well-functioning system of PR-connections, advertising and marketing component. In other words, their valuation depends

very much on some virtual factors. And the latter can be directly influenced, as these companies work in this sphere. Therefore, there are many examples of how purely advertising actions allowed to significantly increase the stock exchange value of such companies, providing them with an inflow of new money and, as a result, leading to significant real financial success.

Thus, more than twenty years of development of the system of information and communication technologies have clearly revealed several regularities following from its internal essential characteristics.

Firstly, in the functioning of this system the components in which the results of the human mind's activity are manifested in 'pure' form (development of various kinds of software, IT services, etc.) play an increasing role.

Secondly, the production and use of mobile means, which allow each person to be involved in the functioning of the 'global mind', are gradually coming to the fore.

And, thirdly, there is an ever-increasing need for new communication capabilities, which give the ICT sphere a truly systemic character. And it is the systemic properties of this element of the noosphere that give the necessary impulses to its development and ensure the efficiency of the latter.

The manifestation of the above-mentioned regularities becomes more and more obvious as the modern system of information and communication technologies as the core of the information society develops.

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PHYSICAL SCIENCES

STUDY OF DIELECTRIC LOSSES AND CONDUCTIVITY OF POLYPHENYLENE POLYMER SEMICONDUCTOR WITH METHOXYL SUBSTITUTES

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ИССЛЕДОВАНИЕ ДИЕЛЕКТРИЧЕСКИХ ПОТЕРЬ И ПРОВОДИМОСТИ ПОЛИМЕРНОГО ПОЛУПРОВОДНИКА ПОЛИФЕНИЛЕНА С МЕТОКСИЛЬНЫМИ ЗАМЕСТИТЕЛЯМИ

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Abstract

The external temperature dependences of $\text{tg}\delta$ and σ in polydimethoxyphenylene are associated with reversible structural changes, which leads to a change in the conditions of charge transfer by π -electrons depending on temperature. With a change in temperature, the number of coplanar π -electrons and their drift mobility change, the sizes of blocks effectively confrontation decrease due to the violation of the coplanarity of π -electrons.

Аннотация

Обнаруженные температурные зависимости $\text{tg}\delta$ и σ в полидиметоксифенилена связаны с обратимыми структурными изменениями, который приводит к изменениям условий переноса заряда π электронами в зависимости от температуры. С увеличением температуры число копланарных π – электронов и их дрейфовая подвижность меняется, размеры блоков эффективного сопряжения уменьшаются вследствие нарушения копланарности π – электронов.

Keywords: Polydimethoxyphenylene, dielectric loss tangent, conductivity, π – electrons, coplanarity.

Ключевые слова: Полидиметоксифенилен, тангенс угла диэлектрических потерь, проводимость, π – электроны, копланарность.

Введение.

Исследование специфических свойств полимеров, особенности полимерных полупроводников. чаще всего приводят к новым рекомендациям для технических приложений этого класса соединений.

Электропроводящие полимеры и на их основе композиционные материалы могут быть легкими и прочными токопроводящими элементами. Они могут быть использованы как антистатические покрытия и материалы, поглощающие электромагнитное излучение в различных диапазонах длин волн.

Ещё давно литературе сообщалось, что в полиазофениленах и полисемихинонах наблюдается обратимое уменьшение проводимости в процессе прохождения через полимер постоянного тока. Показано, что явление не связано с ионным механизмом проводимости и не обусловлено десорбцией газов при прогреве [1,2].

В полифениленах, с боковыми группами в определенных условиях также наблюдается обратимое изменение электропроводности при выдержке образцов в постоянном электрическом поле. Для изучения явления нами привлекались диэлектрические методы исследования, которые могут служить важным источником информации о межмолекулярном взаимодействии. Объекты ис-

следования-полифенилен с метоксильным заместителем, синтезировались в гептане (следует отметить что химический условие получения полифенилена сильно действует его некоторых физических свойств). Измерения проводились на таблетированных порошках и широком температурном интервале и в диапазоне частот $5 \cdot 10^4 \div 10^7$ Гц.

«Q-метр» фирмы ТЕСЛА.

При измерениях получены следующие диэлектрические и электрические характеристики. В температурной зависимости $\text{tg}\delta$ (тангенс угла диэлектрических потерь) обнаруживается максимум (Рис 1). С увеличением частоты измерительного напряжения $\text{tg}\delta$ и максимума уменьшается, а температура, соответствующая этому максимуму и пределах точности измерений, остается неизменной. Последняя зависит от скорости нагрева образца. С ростом скорости нагрева температура максимума увеличивается. При скорости нагрева $0,5$ град/мин максимуму $\text{tg}\delta$ соответствует 40°C . При всех условиях измерений дисперсия емкости не обнаруживается. Из полученных данных следует, что максимум в температурной зависимости фактора диссипации не связан с резонансным поглощением мощности.

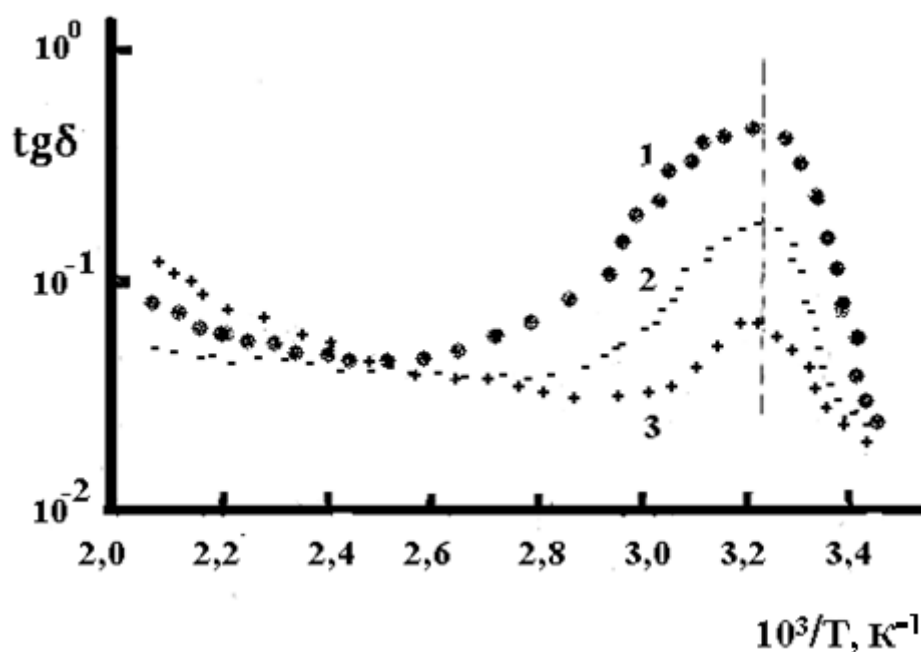


Рис. 1. Зависимость $\text{tg}\delta$ от T при разных частотах
 ν : 1- $5 \cdot 10^4$ Гц; 2- $6 \cdot 10^5$ Гц; 3 – $6 \cdot 10^6$ Гц

При исследовании на постоянном токе в зависимости удельной электропроводности σ от температуры обнаруживается максимум, величина и положение которого также зависит от скорости изменения температуры (Рис. 2).

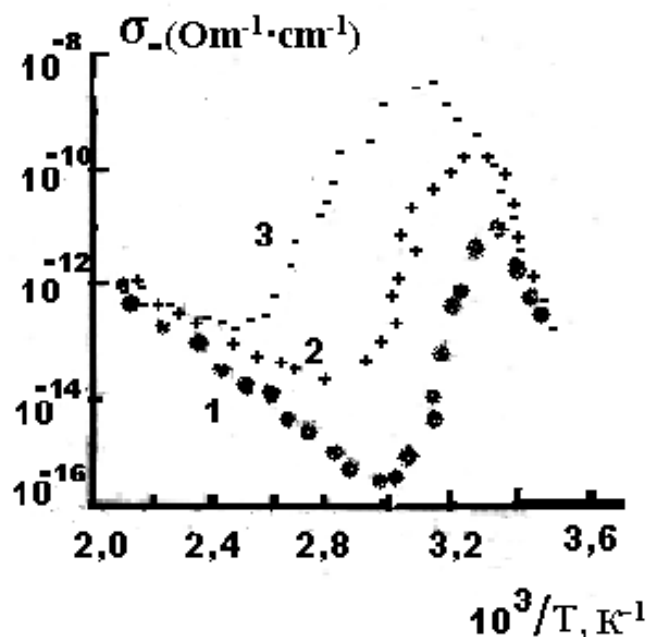


Рис. 2. Зависимость σ – от T
 скорости нагрева: 1 – $0,4 \frac{\text{град}}{\text{мин}}$; 2 – $1 \frac{\text{град}}{\text{мин}}$ и 3 – $7 \frac{\text{град}}{\text{мин}}$

При скорости нагрева 7 град/мин максимуму удельной электропроводности соответствует 60°C . Увеличение скорости приводит к увеличению полуширины максимумов. Наблюдается хорошая корреляция результатов исследований на постоянном токе и диэлектрических измерений.

После прогрева с прохождением максимума и последующего быстрого охлаждения наблюдаются

переходные процессы вблизи комнатной температуры. Обнаруживается спонтанно нарастание $\text{tg}\delta$ и σ электропроводности до исходного стационарного значения. При комнатной температуре стационарное значение достигается в течение нескольких часов. Отметим, что характеристики с максимумом $\text{tg}\delta$ и удельной электропроводности могут быть воспроизведены многократно.

Вводы.

Обнаруженные температурные зависимости $\text{tg}\delta$ и σ в полидиметоксифенилена связаны с обратимыми структурными изменениями и объясняются характером электронного взаимодействия между молекулами. Сейчас твердо установленным фактом является то, что проводимость полимерных полупроводников связана с делокализованными копланарными π - электронами в макромолекулах [3,4,5]. По этому, по нашему мнению наблюдаемые характеристики следует связать с изменениями условий переноса заряда этими электронами в зависимости от температуры. С увеличением температуры число копланарных π – электронов и их дрейфовая подвижность меняется. В области уменьшения проводимости, с ростом температуры размеры блоков эффективного сопряжения уменьшаются вследствие нарушения компланарности π - электронов.

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THE INFLUENCE OF SOLAR CTIVITY ON LEARNING INDICATORS

Bashirov M.,*Candidate of science in physics and mathematics, PhD,***Ahmadova K.***Baku State University, student.**Baku State Universite*<https://doi.org/10.5281/zenodo.11390922>**Abstract**

Just like solar activity, the solar wind affects the physical and magnetic parameters of planets in interplanetary space, sunspots, their number, flares, and magnetic storms created by the Sun on Earth affect radio-electronic devices and the living world. Although the educational indicators of students are associated with physical, sociocultural factors, solar wind indicators do not go unnoticed in these results. In this regard, basic data on the material of the solar wind and geomagnetic storms has been collected. The dependence of such educational indicators as attendance, academic performance, and quality indicators of examination sessions on the parameters of the solar wind and the level of magnetic storm has been studied. Regression dependencies are given, and coefficients are determined. It has been determined that educational indicators depend on parameters related to the sun and the strength of the geomagnetic storm. The results obtained are important when analyzing educational indicators.

Keywords: Sun, geomagnetic storm, education indicators, student attendance, success, quality.

The influence of the solar wind on the Earth makes the study of space plasma relevant in all areas: the formation of geomagnetic storms depending on the intensity of the solar wind plasma, control devices, ground-based complexes, aircraft and control systems, remote control systems, radio engineering, radio navigation, radar and television systems and devices, navigation and affect air traffic control, micro- and nano electronic devices, as well as humans.

Problem Statement. Depending on the time of day, each person's physiological state, intellectual capacity and mood change periodically. Our body temperature depends on the circadian rhythm. We talk about "jetlag" when the body's biological clock operates in one time zone, while other parts of the body - liver, intestines, brain, and muscles - live in a different time zone. Each time zone must be close to the same day for these clocks to synchronize. That is, if a person arrived in a city with a 3-hour difference in time zone, it takes 3 days for the body to adapt. Social jet lag is common for those who must work flexible hours or whose "social" and "biological" clocks are severely out of sync. If your alarm clock goes off before your biological clock asks you to wake up, you are in "social jet lag" mode. Many studies prove that the mismatch between "social" and "biological" clocks increases the risk of depression, heart disease, diabetes, obesity, and even cancer.

Solar activity is determined by flares on the sun. The solar wind is a stream of particles separated from the Sun because of a coronal mass ejection and spread through space. The Sun primarily affects the planets of the Solar System: it makes them revolve around itself due to gravity, the wind it creates causes the loss of planetary atmospheres, changes the magnetic properties and properties of the planets, and creates a magnetic storm on the planets' surface. The solar wind factor also affects living beings. In the works of A. Sakuma, Paris, (1965-1971) on solar activity in geodynamic processes it is shown that as solar activity

increases, there is an activation of mud volcanoes, change in the momentum of gravity, and there is a rise in groundwater during the period of low activity, increased pressure in drilled oil and water wells, natural sources of mineral water. [1]. The influence of solar activity on bio-objects, mental performance of undergraduate students, academic achievement of junior high school students, attendance, and the presence of some diseases in the older age group has been studied. [2, 3, 4]. The effect of solar activity on the spread of pandemics and viruses has also been investigated and it was found that pandemics occur only during minimum periods of solar activity [5]. Solar activity affects the academic performance of students. Seasonal amplification of influenza-like epidemics due to the influence of diurnal resonances of solar activity, the dependence of these epidemics on solar activity was studied, it was determined that the cycle of activity change can coincide with the cycle of impact of other processes in the region, with virus mutation and changes in antigenic drift, and the combination of these mechanisms can cause seasonal epidemics [6]. Factors, problems, and ways of their solution affecting the educational performance of students were analyzed [7], specific factors were studied - the influence of minors on the attendance of classes by the specific value characterizing the magnetic field [8,9]. It is found that attendance significantly decreases when solar activity decreases in younger schoolchildren (9-11 years old). It is mentioned in the paper that solar activity stimulates physical and mental activity in human life. Solar activity directly or indirectly affects the attendance of minors. However, the dependence of students' educational performance on the parameters characterizing solar activity and geomagnetic indicators has not been studied. Thus, studying the educational performance of students in the days before and after a magnetic storm created by the solar wind on Earth is as important as other factors. It is interesting to study the influence of educational perfor-

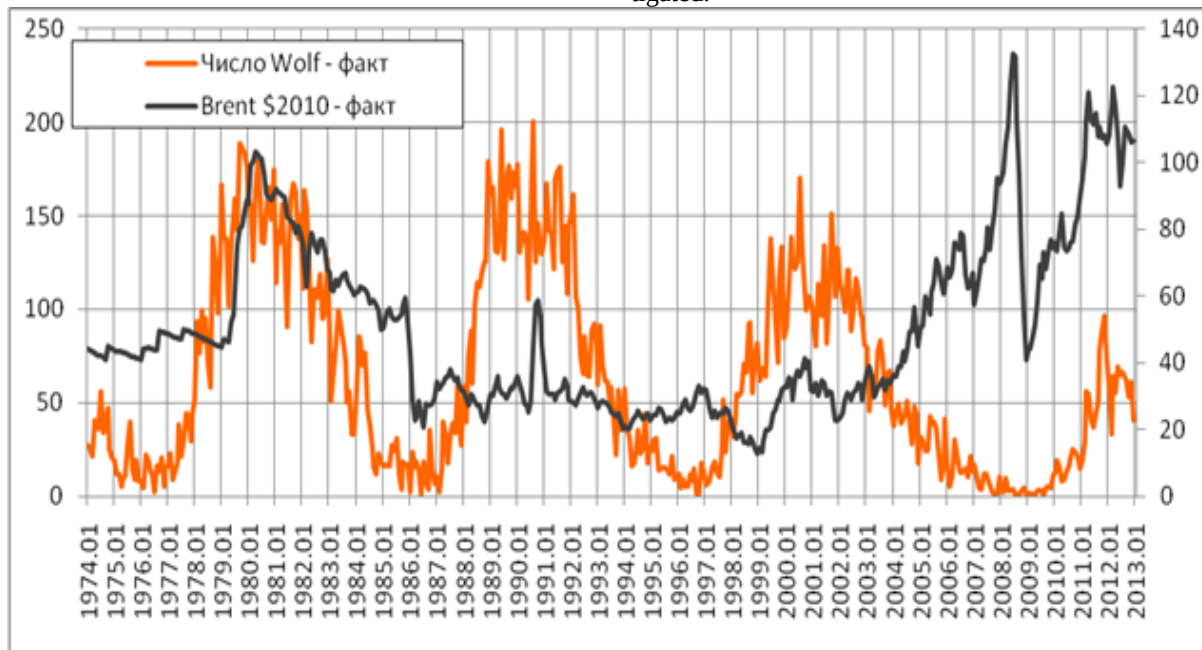
mance of students 18-23 years and older due to the preventive effect of other living things on the event during those times.

There are approaches related to the management of education quality from sociocultural, economic, and other aspects, most of them consider the human factor as a physiological object to improve the quality of education [10]. Man is a physiological object, a biological subject, and his behavior, activity and fulfillment of any needs in a certain sense depend not only on his physical indicators and thoughts, but also on the impact of ex-

ternal physical phenomena. Thus, even though a student who comes to take an exam is fully active during the period of study, the result of the exam may be low and vice versa. A student with less-than-ideal preparation can fully demonstrate the knowledge he/she has.

Sociocultural aspects affect the quality of student management [11]. Manifestation and management of these aspects depends on solar activity in one form or another.

In addition, the influence of solar activity on the sale of goods, oil prices and other facts has been investigated.



The diagram above shows the dependence of oil prices (in US dollars) on the number of sunspots. The increase in oil prices is observed at the maximum value of solar activity. It is noticeable that in areas where oil is required, the requirements of the production process are directly or indirectly dependent on solar activity.

The effect of solar events on educational performance is important. A questionnaire based on related questions was created at docs.google.com.

https://docs.google.com/forms/d/1kS7CVsBnvO8wfcDvtsZIrQsQvmQOciygAd9dDnZ_K2s/edit?ts=65798dad#responses, Information was collected and analyzed from 150 people.

1. Can events happening on the Sun affect the Earth and us? Yes, no, I can't say.

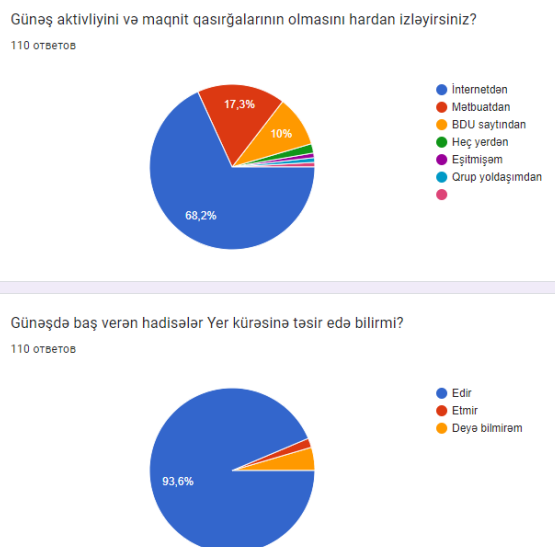
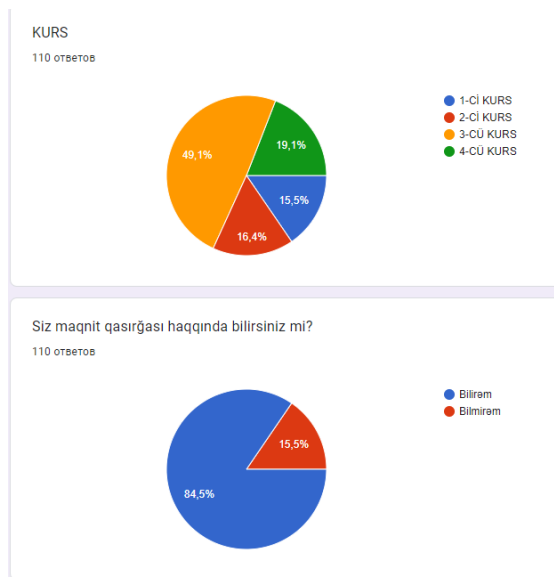
2. Do you know about magnetic storms? Yes, I know, No I don't know.

3. Where do you keep track of solar activity and magnetic storms (from the press, Internet, Baku State University website or other source)?

4. How does a magnetic storm affect your life (Yes, I know, No I don't know).

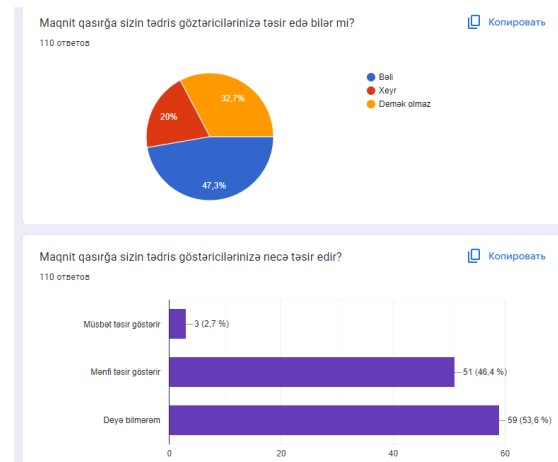
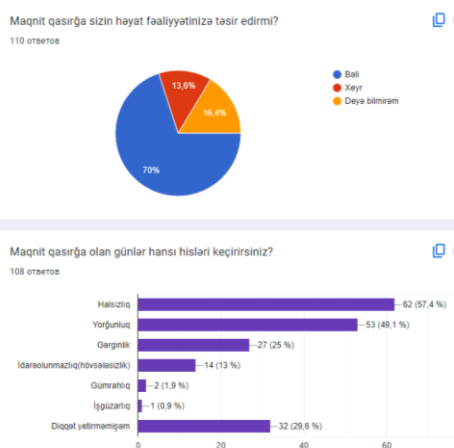
5. What feelings do you experience in days of magnetic storm, for example, weakness, fatigue, tension, uncontrollability (despair), vigor, business? (I haven't noticed any).

6. Can a magnetic storm affect your academic performance? Yes, no, I don't know.



The survey covered all undergraduate courses of Baku State University, 15.5% of I (first) year, 16.4% of II year, 49.1% of III year and 19.1% of IV year students participated in the survey. The survey was analyzed, answers to the questions about solar activity, magnetic storm, its influence on the Earth and people were analyzed, and the corresponding diagrams were constructed. As can be seen from the diagrams, the fact that the respondents have information about magnetic storms is 84.5%. The survey participants stated that they follow the information about solar flares and magnetic storms on websites and in the press. Respondents believe these events affect the Earth (93%) and even

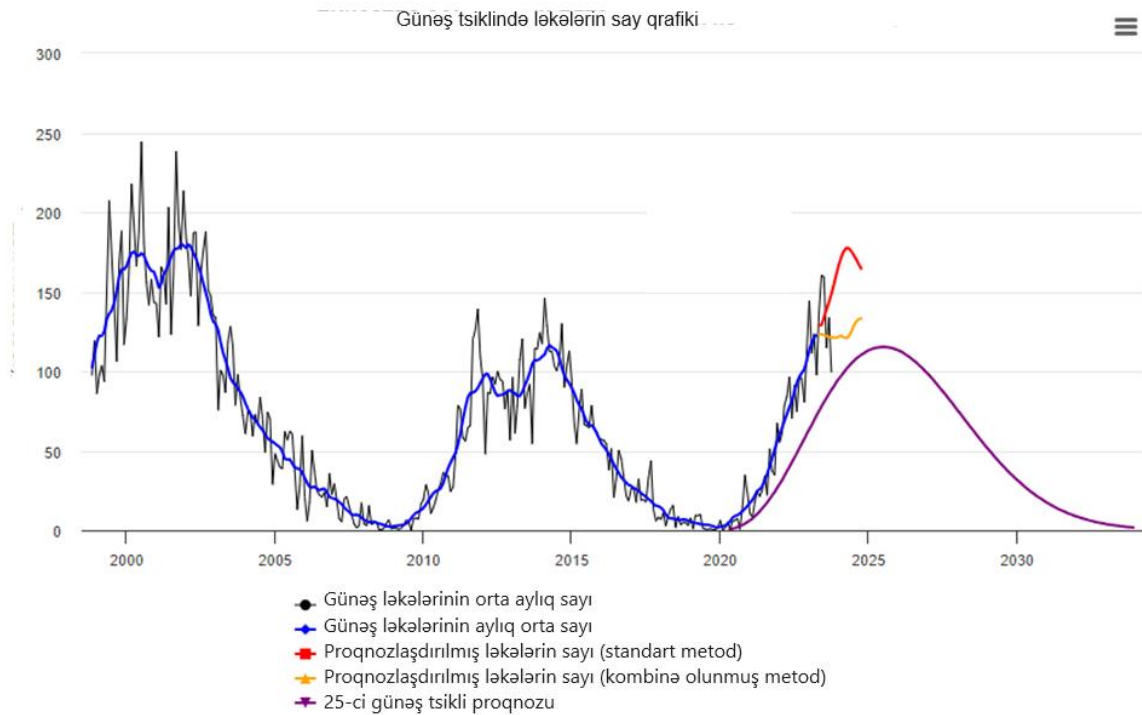
say they play a role in their daily activities (70%). During a magnetic storm, when sunspots and flares are high, 57% of respondents said they felt weak, 48% felt tired, 27% felt stressed, and 14% felt discouraged and out of control. 47% of them stated that these events also affected their academic performance and 20% stated that they did not. 3% of respondents stated that it had a positive effect and 51% stated that it had a negative effect. The fact that students are aware of related events is satisfactory. All this puts on the agenda the importance of studying the effect of solar phenomena on people, their daily activities as well as educational performance.



Actuality. Along with other facts that influence educational performance: lifestyle, mental potential, physical condition, motivation, financial opportunities, whether education is targeted or not, external influences: family, relatives, acquaintances, society, political events, etc. along with such facts, the influence of the closest star to the Earth, the Sun, is invaluable. Both the gravitational and electromagnetic properties of the Sun, as well as the fact that the Earth is inside the Sun's atmosphere, means that any process occurring on the Sun does not affect the Earth. Solar activity, solar wind strongly affects electromagnetic devices, satellites, stations, unmanned aerial vehicles, satellites, astronauts on Earth and traveling in Earth orbits. The power of the

impinging particle flux is important for displaying the aurora borealis: when the particle flux power is less than 20 kW, the aurora borealis is not visible. It is visible when it is between 20-50 kW, and when it is between 50-100 kW, auroral movement is observed. This power must be greater than 100 kW for a magnetic storm to occur.

These effects are especially evident when the older generation is on different forms of learning. Thus, students and teachers 65-75 years old cannot manage their learning activities and outcomes related to the facts arising from various health problems on days of increased magnetic activity.



<https://www.spaceweatherlive.com/ru/solnechnayaaktivnost/solnechnyy-cikl.html>

From the graph taken from the site, we can see that by periods of solar activity 2023-2028 years will coincide with the period of increased activity. This fact is confirmed by both the forecast and actual observations. Judging by the graph, the actual observed activity level is higher than the predicted values. This makes the study of events related to solar activity more relevant.

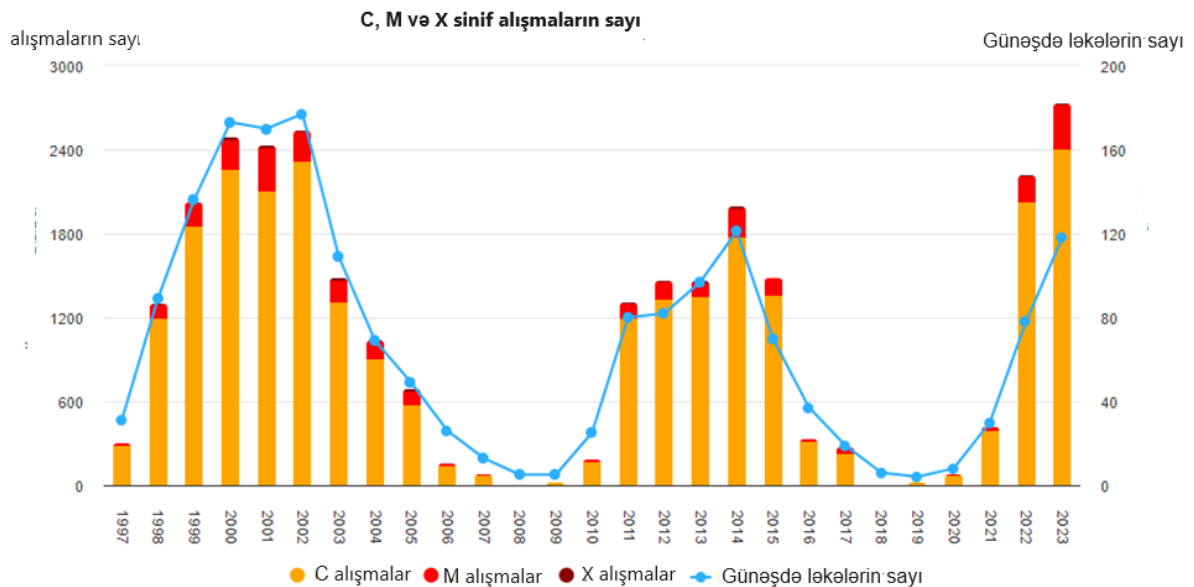
Table

Wolf number (number of observed sunspots) in 2000-2023.

	yanvar	fevral	mart	aprel	may	iyun	iyul	avqust	sentyabr	oktyabr	noyabr	dekabr
2000	90	113	139	125	122	125	170	131	110	99	107	104
2001	96	81	114	108	97	134	82	106	151	126	106	132
2002	114	107	98	121	121	88	100	116	109	98	95	81
2003	80	46	61	60	55	77	85	73	49	66	67	46
2004	37	46	49	39	42	43	51	41	28	48	44	18
2005	31	29	24	24	43	39	40	36	22	8	18	42
2006	15	5	11	30	22	14	12	13	14	10	22	14
2007	17	11	4	3	12	12	10	6	2	1	2	10
2008	5	4	16	5	6	4	1	0	1	5	7	1
2009	2	2	1	1	3	3	4	0	4	5	4	11
2010												
2011												
2012												
2013	13	19	16	8	9	14	16	20	25	24	22	14
2014												
2015	19	30	56	54	42	37	44	50	78	88	97	73
2016								51	42	33	23	22
2017	27	22	20	31	20	21	20	27	45	18	14	15
2018	13	16	11	13	17	19	11	14	12	13	13	13
2019	16	11	21	13	16	12	12	11	12	11	12	12
2020	13	11										
2020	13	11	12	14	11	12	13	15	11	20	36	
2021	7	6.	11	19	16	20	24	16	39	27	27	51
2022	44	49	59	59	73	59	77	63	73	27	54	94
2023	113	90	85	72	121	134	152	146				

The size of ordered regions on the surface of the Sun, the number of spots in a region, their magnetism, their classification, and the probability of ignition occurring in each of them are different. The regions can be expanded and separated. The number of sunspots, their total area, the number of new group formations and the number of spots in each group, the radio emission wavelength (cm), and the classification of

sunspots according to the Zurich/Mackintosh system change every day. At present, the number of sunspots, the real average monthly sunspot number, and the number of average monthly sunspots are increasing according to standard and other methods. This occurs according to the 25-year cycle of solar activity. Since the maximum of the 11-12-year cycle falls on 2025-2026, the relevance of this issue arises.



The graph above shows the number of C, M, and X class flares that occur on the Sun and can affect Earth.

Solar flares: Solar flares are divided into five classes: Class A and B flares are quiet flares, Class C flares are weak flares, Class M flares are strong flares, and Class X flares are the main class of very strong flares. Each flash class is distinguished from 1 to 9: A1, A2,..., A9, B1, B2, ...B9, C1, C2,..., C9. X-class dependency types continue. For example: flashes X10 and above are called "super X-class flashes". Class A and B flares correspond to minimum and maximum solar background levels and are not of interest for research. Class C flares are practically incapable of affecting the earth. While it cannot affect the earth, radio wave propagation and electronic devices, it does not affect living things. Class M flares are weak and effective (R1-R2) and can block and even disrupt radio wave propagation. Moderate M-class flares can create a solar radiation storm. Strong and persistent M-class flares can cause a CME (coronal mass ejection).

Class X flares are the largest and most powerful. This class of flares occurs about 10 times a year and is

mainly observed during solar maximum. When an X-class flare is received, the radio wave propagation barriers at the Earth's daytime surface (R3-R5) increase from strong to higher-extreme levels. If this flare were to occur in the middle of the Earth-facing solar disk, a strong, persistent solar radiation storm would form and a strong CME would occur, which could cause a geomagnetic storm from strong (G4) to extreme (G5) on Earth.

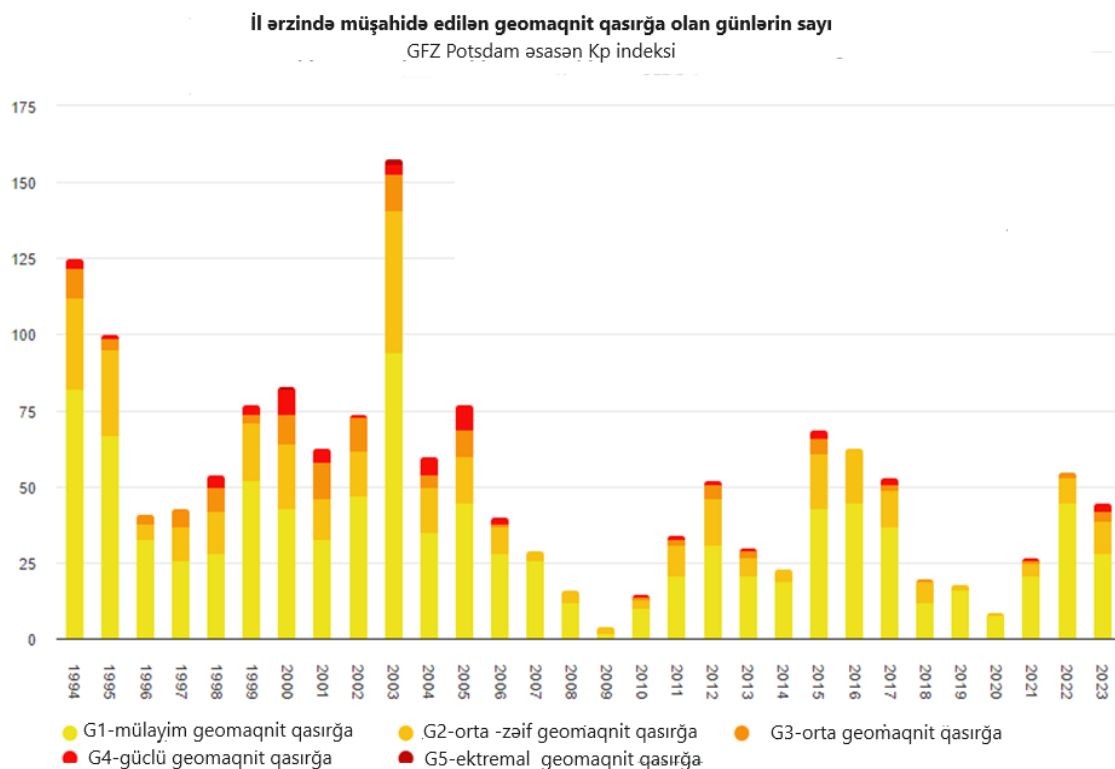
The solar wind causes geomagnetic storms on Earth. It is characterized by the Kp coefficient, which indicates the strength of the storm. Kp indicates the predicted geomagnetic conditions at mid and high latitudes. These values indicate the expected geomagnetic activity for the next 3 days with a 3-hour period. This is the easiest way to find out what the geomagnetic conditions will be like over the next 3 days. Forecasts are updated daily by the NOAA SWPC (National Oceanic and Atmospheric Administration National Space Weather Prediction Center) (data taken from the Baku State University website).

Table

Dependence of magnetic storm magnitude on the value of Kp

Kp	0-2	3-5	6-7	8-9	9
Storms	quiet	weak	average	strong	powerful
G		Kp=5, G1	Kp=6, G2 Kp=7, G3	Kp=8, G4	Kp=9, G5

As of November 2023, the last strongest flare X1.51 occurred on 01.08.2023, flare M9.8 - 28.11.2023, geomagnetic storm Kr(G2) - 25.11.2023. In March 2024 there were flares X1.1, M9.5, there was a geomagnetic storm K2(G6).



The diagram above shows the dependence of the number of geomagnetic storms by years. As can be seen, the number of geomagnetic storms of G1 and G2 class prevails in the last year.

Table

Solar flares and geomagnetic activity

year	Flashes			Number of sunspots	The level of the magnetic storm				
	C	M	X		G1 weak	G2 Average weak	G3 medium	G4 is powerful	G5 emergency
1994					94	47	12	3	2
1995					67	28	4	1	
2003					82	30	10	3	
2017	237	22		19	37	12	2	2	
2018	192	15		6	12	7	1		
2019	56	5		4	16	2			
2020	81	3		8	8	1			
2021	398	21		30	21	4	1		
2022	2036	178	7	78	45	8	2		
2023	2411	315	11	118	28	11	3	3	

The characteristic table given for the values of solar wind parameters includes solar wind speed, plasma flux density, and other parameters. An increase in these parameters is observed during a magnetic storm.

Solar wind parameters	yaxşı	orta	pis
Solar wind speed x100km/s	0-4	4-7	More than 7
Wind density	0-12	12-24	More than 24
Pressure nPa	0-4	4-8	More than 8
Magnetic induction of the interplanetary medium nTl	0-9	9-21	More than 21
Pole induction angle	0-40°	40°-48°	More than 48°
Pole voltage x10kV	0-11	11-20	More than 20
Particle flux power at the pole QW	0-50	50-100	More than 100

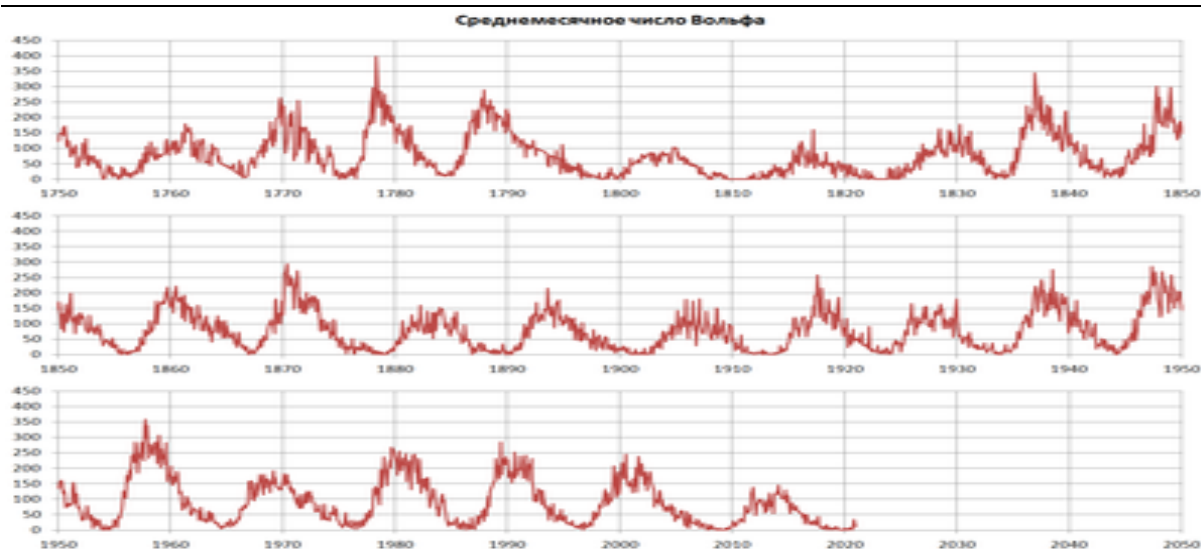
What happens during a geomagnetic storm and what advice do doctors give during a geomagnetic storm? Geomagnetic storms caused by solar flares can have a negative impact on human health. These storms can cause headaches, insomnia, severe uncontrollable agitation and other unpleasant symptoms. In this case (a) it is recommended to drink more water, which reduces the impact of the geomagnetic storm. Water improves blood circulation and reduces muscle tension. During a geomagnetic storm there is fatigue and increased excitement, so it is considered advisable to refrain from heavy physical exertion and sports during these days. People suffering from any illnesses should be more careful on geomagnetic storm days and consult a doctor when symptoms appear. They should be out in the fresh air. Fresh air relieves stress and reduces tension. Rooms should be ventilated if you feel discomfort on geomagnetic storm days. Healthy food can reduce the negative conditions that occur in the body during a geomagnetic storm. If you pay attention to these facts and eat healthy fruits and vegetables, you can prevent and reduce the effects of geomagnetic storms. All of these factors have a significant impact on a student's academic performance.

Research Objective. Solar wind, magnetic storms respond by preventive effects on various organisms and microbes. Colors, shape, etc. change its parameters. Naturally, such changes lead to the manifestation of

various diseases in the human body. The number of one or the other diseases increases. Accordingly, it does not affect the educational indicators. Ultimately, all these facts affect the educational performance of students. If we compare the time that students devote to learning (35-45% of the day, more in high schools), we can see how important it is to study the impact of the above-mentioned phenomena on the learning process.

It should be noted that the logarithmic coefficient of magnetic storm intensity K_r varies from region to region. The coefficient depends significantly on whether the locality is near or far from the Earth's pole. For this reason, in the work we analyzed, the coefficients were taken by region.

The temperature on the surface of the Sun varies, and areas whose temperature differs from the surface temperature by 1500-2000 K are registered as spots. The sunspots appear black on the Sun. Groups of spots are sorted and listed. Spot clusters are labeled as regions. Spot groups are numbered throughout the year, each characterized by activity, number of spots per area, area, location, spot shape, tendency to disperse, and other factors. Spots also vary in width, length, and depth. These spots have a certain depth at the surface of the Sun. (<https://rg.ru/2023/12/06/dyra-na-solnce.html>) The last coronal hole was observed in March 2023, after which solar activity increased.



Solar activity is characterized by the Wolf number by the number of spots on it. The Wolf number is defined as $W=k(f+10g)$: f is the number of observed spots, g is the number of observed groups of spots, and k is the normalization factor

<https://www.spaceweatherlive.com/ru/otchety/otcheto-solnechnyh-pyatnah.html>

Research. The immediate possibilities of research questions study were evaluated. As a first step it was planned to study educational indicators of separate groups of specialties of the faculty: students' attendance, educational indicators, attendance of examination

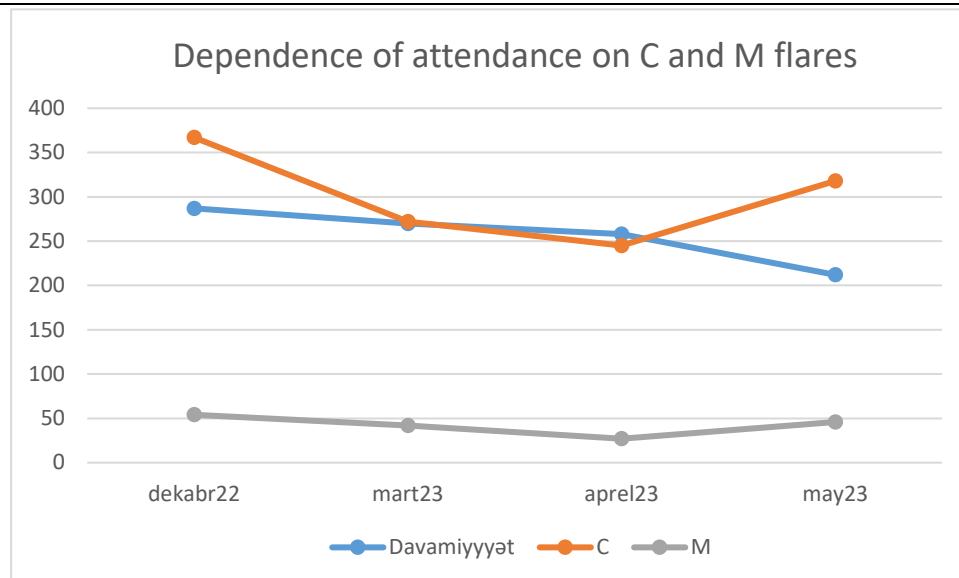
sessions and performance indicators. For this purpose, the dependence of indicators on the Kp coefficient for the months of December-January, March, April, May and June of different years was studied. Kr coefficient fixed for Baku city was taken.

The attendance of 20 academic groups for different four months was taken and a diagram of average monthly grades depending on the habits of C and M was plotted. It covers December 2022, March, April and May 2023. Since there are no classes in January-February 2023, these months are not shown.

Table

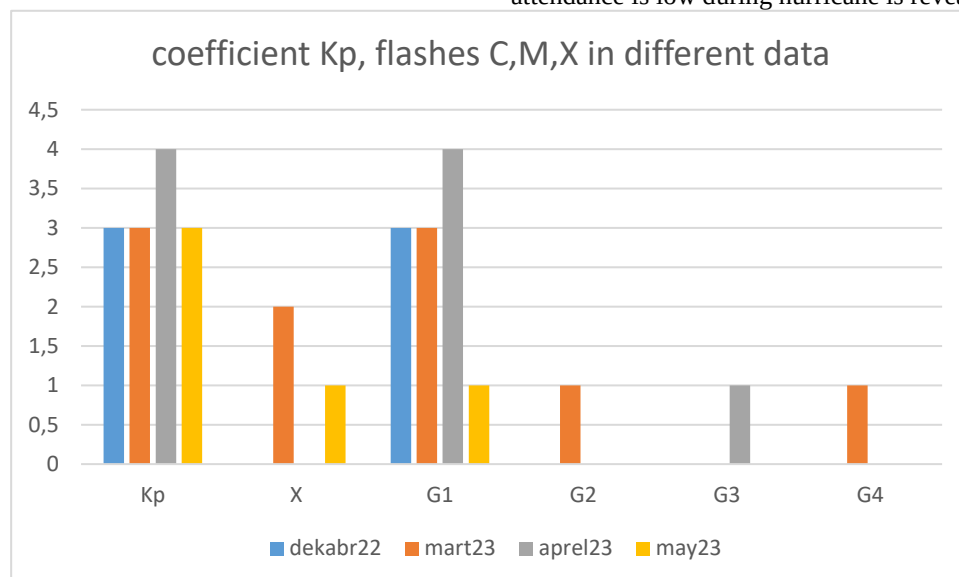
Monthly attendance (number of absences) and number of outbreaks for the 2022-2023 school year

		2022	2023		
	GROUP	DECEMBER	MARCH	APRIL	MAY
1	211	232	196	135	182
2	212	370	277	162	227
3	213	130	125	108	93
4	214	286	214	270	207
5	215	390	610	472	300
6	216	170	227	186	145
7	217	114	145	285	186
8	218	112	131	244	194
9	219	466	300	352	434
10	220	253	165	176	312
11	231	356	432	368	260
12	232	246	308	312	196
13	233	316	325	360	275
14	234	528	264	384	236
15	235	550	268	376	240
16	236	288	400	280	264
17	237	348	344	108	164
18	238	176	176	192	76
19	239	193	276	200	172
20	240	225	220	208	92
	total	5749	5403	5178	4255
	average D	287	270	258	212
	Kp	3	3	4	3
	C	367	272	245	318
	M	54	42	2	46
	X		2		1
	The number of spots	94	85	72	121
	G1	3	3	4	1
	G2		1		
	G3			1	
	G4		1		



As can be seen, the decrease in C and M fires corresponds to a decrease in attendance. In the latter part, C and M increase sharply and attendance decreases sharply. Compared with the magnetic hurricane index

Kr, ignition X and the number of occurrence of hurricanes G1 and G2 in April, the Kr coefficient and the number of occurrence of hurricanes G1 are higher and the attendance is lower in these months. The fact that attendance is low during hurricane is revealed.



Let's use the regression formula used in statistical processing of data. First we will consider the linear regression dependence.

To study the regularity of changes, we will write the regression formula and determine the regression coefficients:

$$TG1 = TGo1 - a1Kp^{n1} - a2A^{m1} - a3V^{p1} - a4C^{g1} - a5M^{r1} - a6X^{h1}$$

$$TG2 = TGo2 - b1Kp^{n2} - b2A^{m2} - b3V^{p2} - b4C^{g2} - b5M^{r2} - b6X^{h2}$$

$$TG3 = TGo3 - c1Kp^{n3} - c2A^{m3} - c3V^{p3} - c4C^{g3} - c5M^{r3} - c6X^{h3}$$

TGoN - initial value of educational indicators. aN, bN, cN, etc. as well as ni, mi, gi, ri, hi, etc. coefficients represent the degrees of parameters (N, i = 1, 2, ...) on which the corresponding educational indicators can depend. Kr, A, B, C, M, X are the number of geomagnetic indicators, spots and corresponding fires, respectively.

The initial values can be taken as maximum, and it can be assumed that these other factors are ignored. TGoN=100%.

TG1 is attendance (D), TG2 is success (M), TG3 will represent quality (K). From the basic data collected, as many of these equations as possible were solved for each indicator and linear regression coefficients were determined.

$$D = Do + c1L + c2C + c3M + c4X$$

$$M = 100 + a1L + a2C + a3M + a4X$$

$$K = 100 + b1L + b2C + b3M + b4X$$

The dependence of success and quality percentages in different courses on the number of sunspots in years has been established.

If we systematize the data and solve together, for the quality parameter.

$$K = 100 - 3.5L - 0.3849C + 4.7600M - 15.657X$$

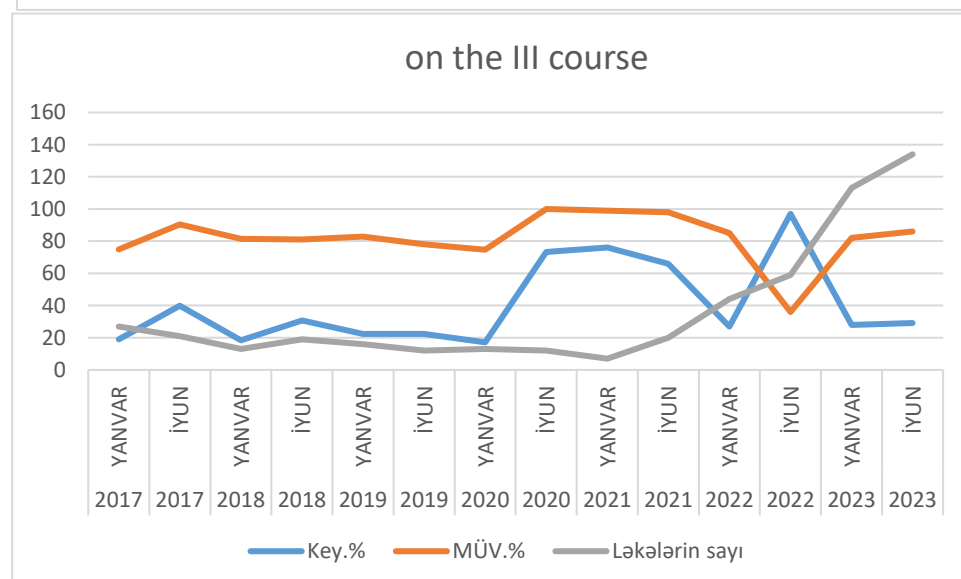
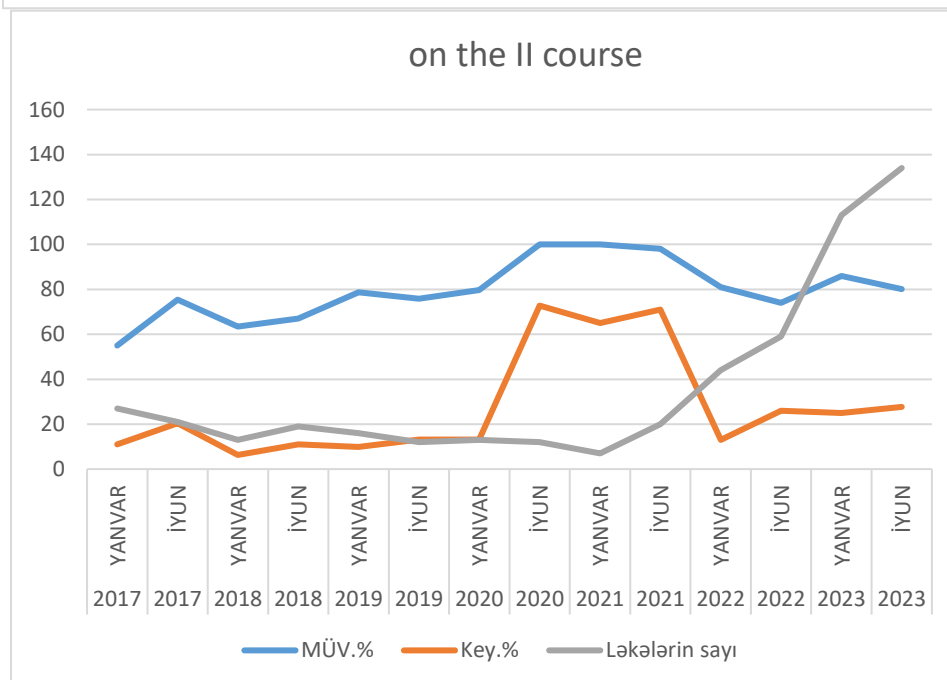
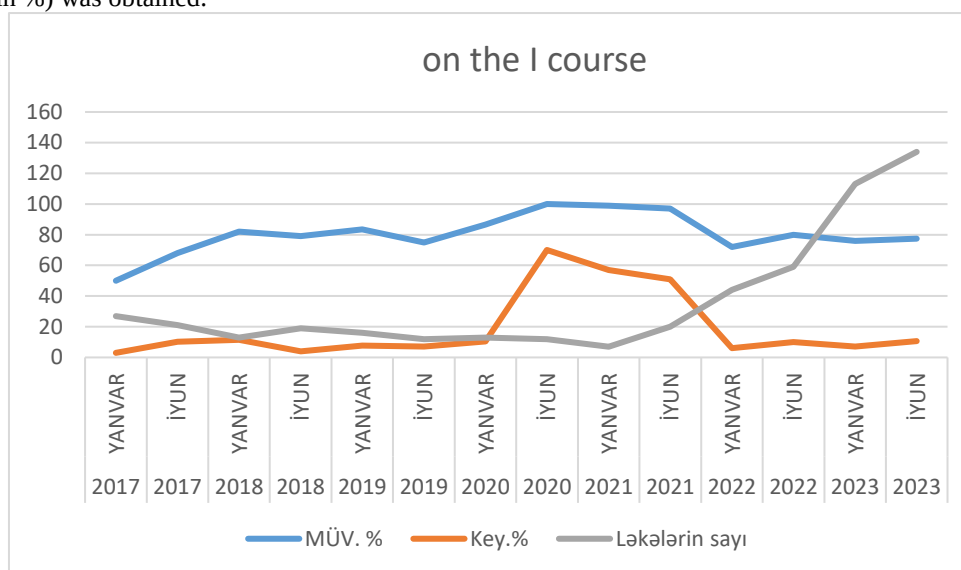
for the performance parameter we obtain the following expression

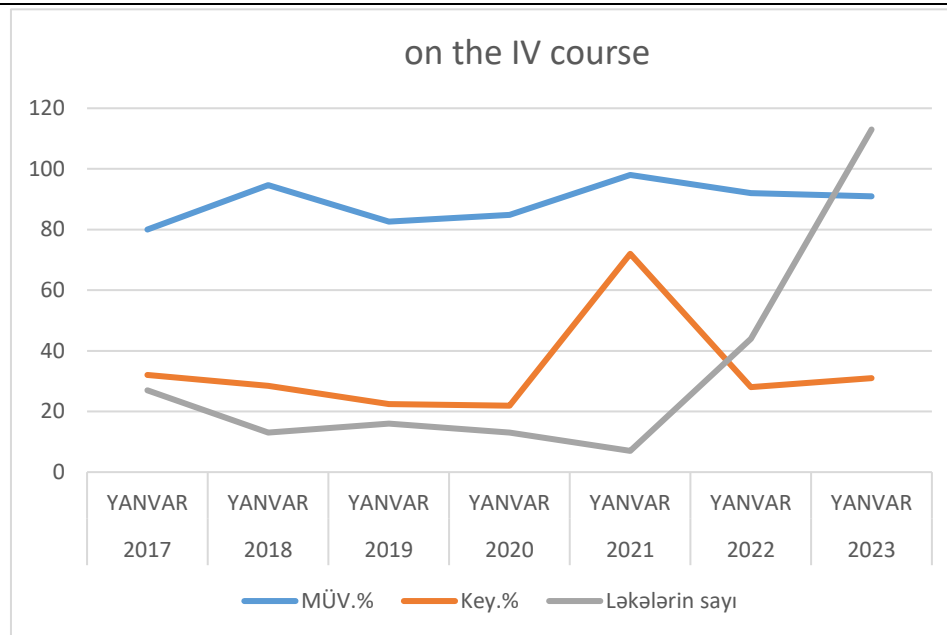
$$M=100-0,095L-0,1476C-2,2077M+8,806X$$

A regression expression of the dependence of attendance (percent of attendance) on solar activity parameters (in %) was obtained.

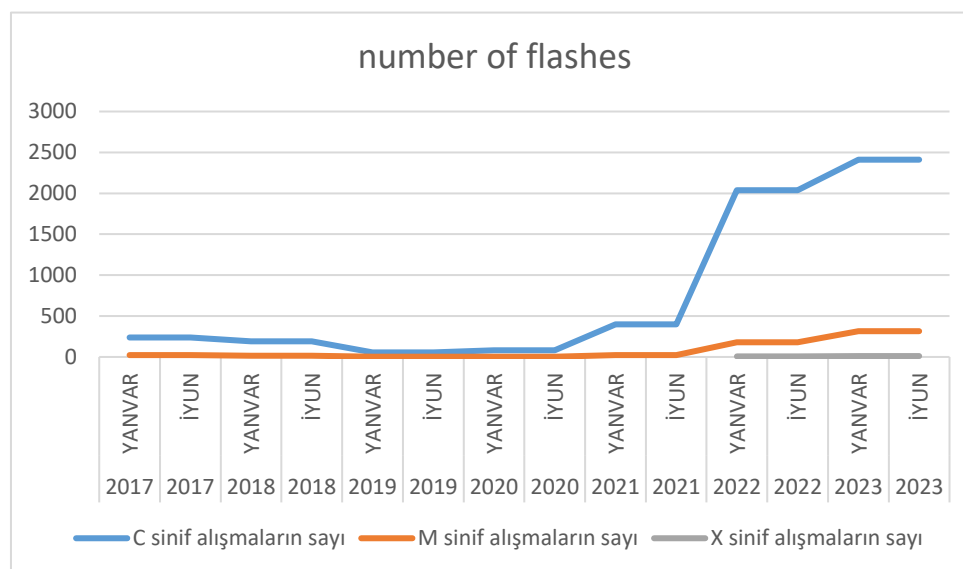
$$D=0,77866L+0,23544C-1,35486M+8,073X$$

L is the number of spots, C, M and X are the number of outbreaks during this period.





From the charts, we can see that the success rate is directly related to the number of spots with small errors. As the number of spot numbers increases, the success rate also increases. In 2020-2021, due to the pandemic, we do not consider the values of learning rates suitable for study, so we will not consider the dependencies falling in this part.

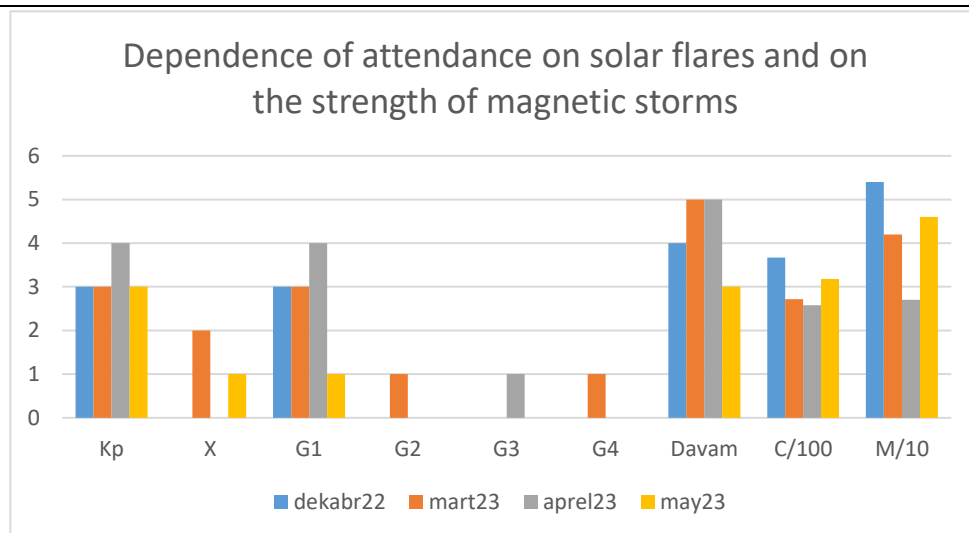


The last chart shows the number of solar flares over the years. The charts show that as the number of rolls increases, the quality and success rate partially decrease, and as the number of rolls decreases, these indicators generally decrease. Given that 2020-21 falls during the pandemic period, the fluctuations are. On February 2, 2023, and June 16, 2023, unlike other exam

days, the Kr factor was 5. Other exam days had 2, some 3 - 4. It was observed that the average monthly number of spots and number of C outbreaks were higher in these months than in other months. The number of spots and the number of outbreaks on these days are given in the table below.

date	Kp	success%	qualities%	L monthly	L	C monthly	C	M monthly	M	X monthly	X
02.02.23	5	88,9	40,6	49	19	2036	3	178	-	7	-
16.06.23	5	94,4	75,8	134	32	2411	10	315	3	11	-

As the number of monthly and daily commercials, monthly and daily C burns increased, there was an increase in success rates and quality.

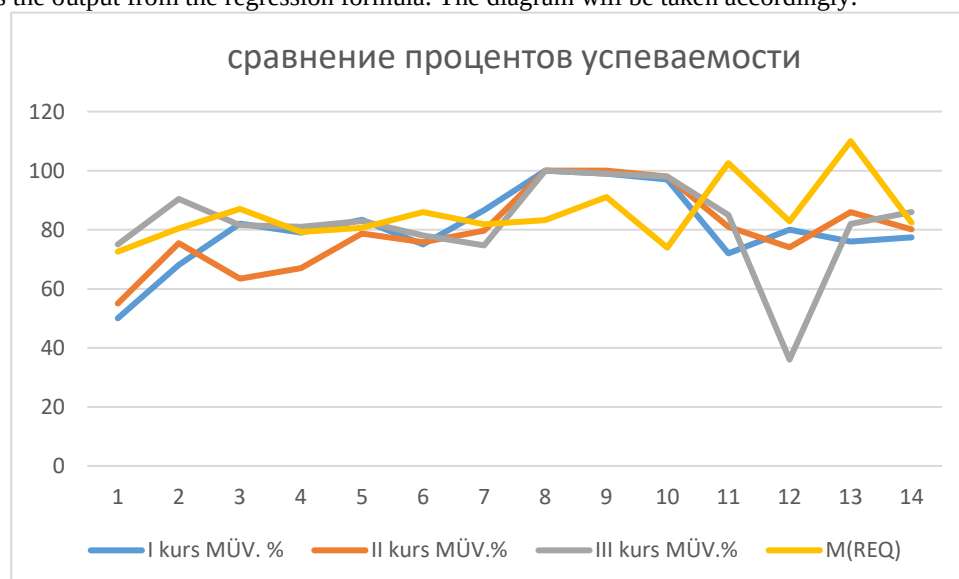


As can be seen from the diagram, as the Kp coefficient and the number of magnetic storms G1 increase, attendance decreases, and absenteeism increases. However, the average number of failures is inversely proportional to the number of C and M connections. As the number of C and M connections decreases, the number

of failures increases. This chart is based on figures for December 2022 and March, April, and May 2023. As attendance increases, truancy decreases, which is the opposite of attendance, it is natural that students continue to attend classes and other indicators of educational attainment increase.

sN	years	months	I kurs ac.p. %	II kurs ac.p. %	III kurs ac.p. %	Academic performance M(REQ)
1	2017	YANVAR	50	55	75	72,56976
2	2017	İYUN	68,1	75,4	90,4	80,46216
3	2018	YANVAR	82,1	63,4	81,5	87,09536
4	2018	İYUN	79	67	81	79,20296
5	2019	YANVAR	83,39	78,69	82,94	80,69868
6	2019	İYUN	75	75,82	78	85,96028
7	2020	YANVAR	86,67	79,68	74,69	81,89348
8	2020	İYUN	100	100	100	83,20888
9	2021	YANVAR	99	100	99	91,06904
10	2021	İYUN	97	98	98	73,96884
11	2022	YANVAR	72	81	85	102,59318
12	2022	İYUN	80	74	36	82,86218
13	2023	YANVAR	76	86	82	109,97538
14	2023	İYUN	77,35	80,07	85,97	82,35198

M(REQ) is the output from the regression formula. The diagram will be taken accordingly:



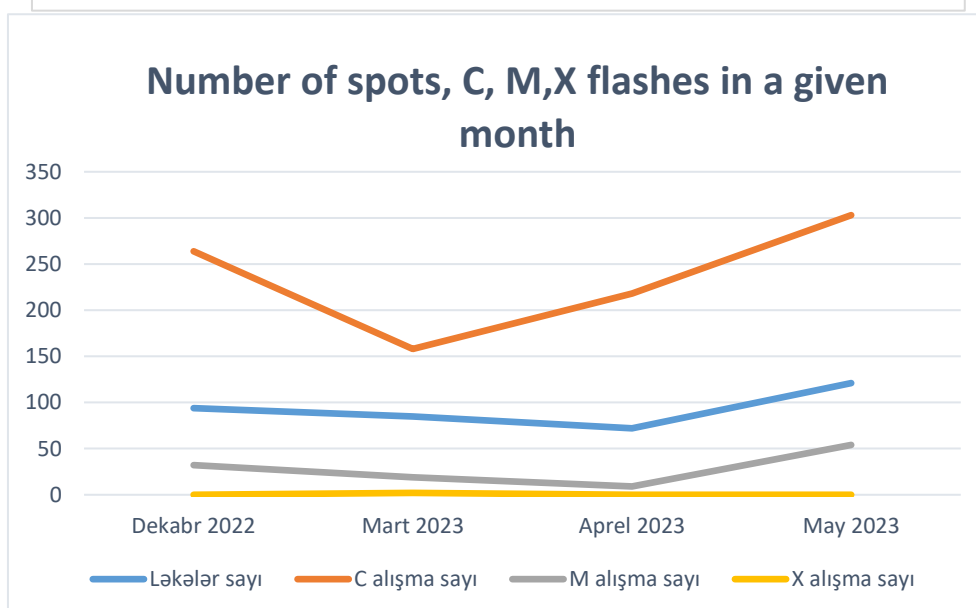
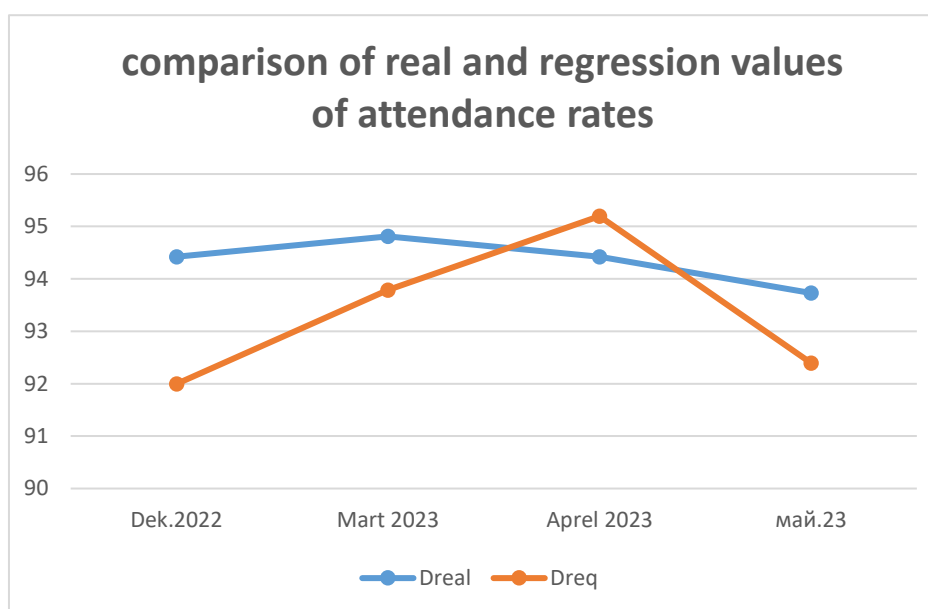
The regression formula allows us to find the success rate by the number of spots, C, M and X ignitions. In parts 8-9-10, the sharp difference between the real results and the results obtained by the regression formula coincides with the pandemic period. During this period, exam performance, such as natural online exam results, should have been different from real exam performance. In other parts, there are variations depending on the courses. If deviations from the mean are not considered, the regression formula obtained for the success rate can express the relationship.

The obtained statements differ from the real values by 5-12%.

The differences in the quality percentages are larger. Differences of 20-30% were found between the regression expression and the real values. This shows that the quality indicator is more dependent on other factors more important and dominant than solar flares.

For December 2022, March, April, and May 2023, the average scores of the 20 groups were taken and the scores were compared with the regression expression derived from the previous attendance and parameters (Table).

time	Dekabr 2022	Mart 2023	Aprel 2023	May 2023
Number of spots	94	85	72	121
Number of flashes C	264	158	218	303
Number of flashes M	32	19	9	54
Number of flashes X	0	2	0	0
date	Dekabr 2022	Mart 2023	Aprel 2023	May 2023
D(real)%	94,42	94,81	94,42	93,73
D(req)%	91,99468	93,78928	95,1957	92,39374

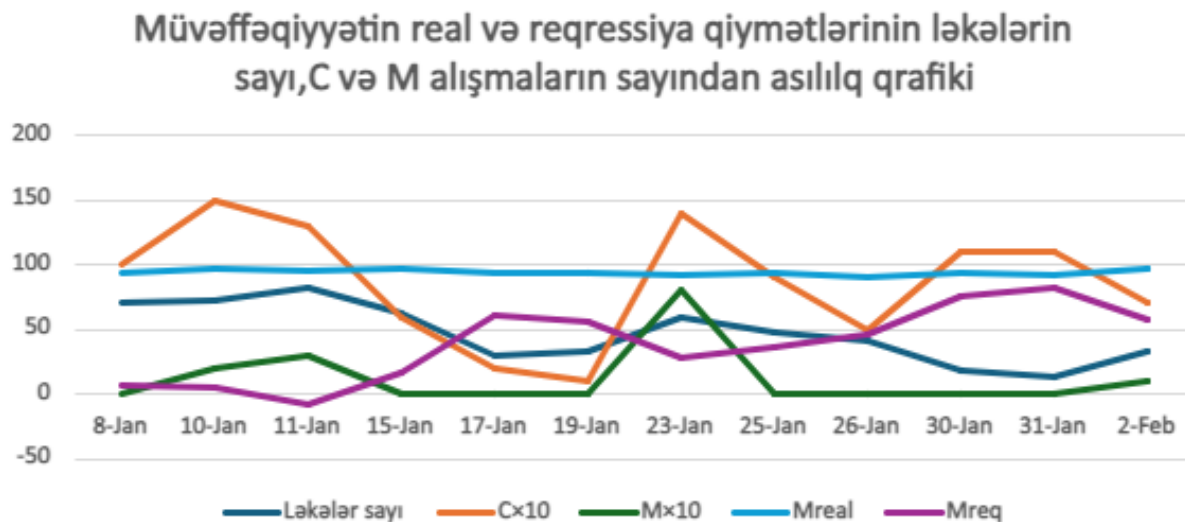


It can be seen from the diagrams that the percentage of attendance decreases as the number of ignitions increases and increases as it decreases. This can be seen in both the real and dependent diagrams of the expression obtained from the regression formula. The real prices differ from the theoretical ones by a maximum of 2.5%.

At present, solar activity continues to increase and this activity will be felt in the next 8-10 years. Therefore, it is important to study all areas that can be affected by solar activity. The results obtained will make

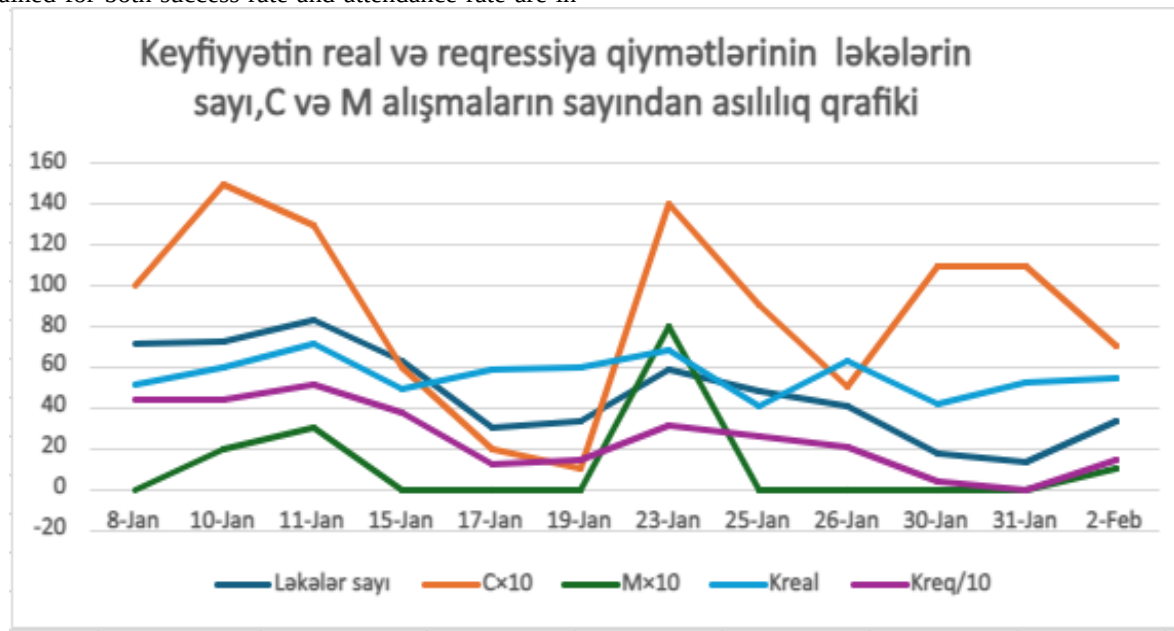
it possible to make forecasts of educational indicators taking into account solar activity.

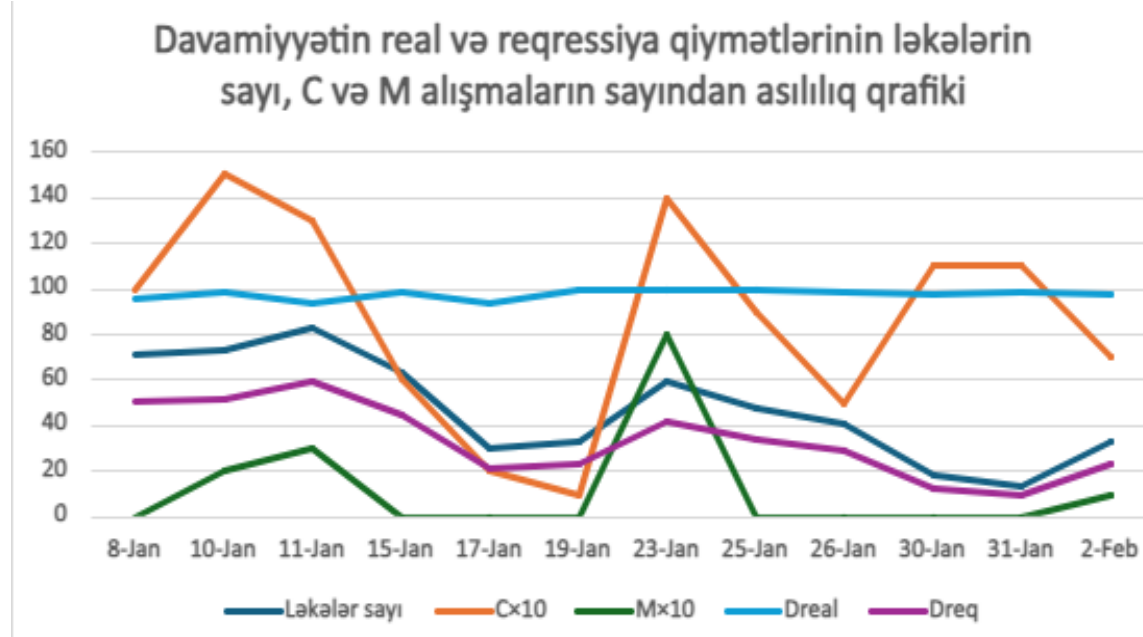
We applied the resulting regression formulas to the January 2023 test session scores. The charts below show the dependence of attendance and success rates on the number of sunspots and the number of C and M classes during the test session. As you can see, the real value of the success rate depends on the number of spots. Of course, it must be with a lag that shows its effect. The effect of the number of sunspots on the Sun today is evident in the next 3-4 days. The changes caused by spots affect the Earth in 3-4 days.



This fact is also manifested in the attendance rate. So, the amount of spot changes affects the prices after 2-3 days. The changes in the regression expressions obtained for both success rate and attendance rate are in

the same harmony with the changes in real values. The change in the regression expression for a small percentage of changes in real prices is more noticeable.





Many factors influence the educational performance of students. If we consider the human factor, there are fuzzy factors in these processes. Most of all other factors depend on solar factors. Taking all these into consideration, it can be said that sunburn, sunspot number affect the educational performance. This should be studied and researched more comprehensively.

Result.

Educational performance of students in the age group 18-22 years directly or indirectly depends on the parameters of the solar atmosphere, the number of sunspots and flares, the strength of geomagnetic storms caused by solar wind and coronal mass ejections.

Attenuation (number of absences) depends on parameters indicating changes in the Earth's magnetic field: The number of sunspots is directly proportional to the number of class C flares.

As the number of sunspots, the number of Class C and M burns change, the test results also change by a certain percentage on those days, 3-4 days before the day of the hurricane and 3-4 days after the hurricane.

There is already an increase in sunspots and sunburns increasing student performance and quality scores.

Sunburns are believed to affect the human body at the nano level, causing changes in the functioning of human organs and causing them to deviate from the norm.

In order to obtain more effective research results, it is planned to prepare more databases, and at the same time to study the dependence of educational indicators on other solar wind parameters.

Changes in the environment are inevitable. But as a result of our irresponsibility and negligence, these changes are becoming tragic and widespread. Some tragedies can be prevented, some can be protected, some can be reduced in complexity, and some can be made prettier and simpler by removing the factors that hinder our development. The listed events and studies

show that it is geomagnetic conditions that can lead to emergencies of various types.

It is the change in the Sun's activity, especially its decrease, that leads to a decrease in the activity of many events occurring on Earth, a decrease in epidemics and airplane accidents. Solar activity stimulates people, their physical and mental activity, and directly or indirectly affects continued learning and outcomes. Humans have adapted to solar events that have and will continue to occur throughout their lives and have experienced changes in this form. As such, solar phenomena should not be a cause for concern. Solar phenomena should be studied more carefully, and the facts obtained should be applied for use in everyday life.

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SOCIAL SCIENCES

HISTORICAL AND GEOGRAPHICAL REVIEW OF WESTERN AZERBAIJAN

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Abstract

The historical and geographical environment of Western Azerbaijan is investigated in the presented article. On this basis, the historical past of the region is analyzed, and extensive information is provided about the natural-geographical conditions and population. As a result, the cultural aspects of the historical-geographical conditions are mentioned.

Keywords: Western Azerbaijan, history, geography, culture

INTRODUCTION

The lands of Azerbaijan have witnessed many events throughout history. The most important of them were the agreements based on the distribution of our lands:

- 1813 – Gulustan;
- 1828 – Turkmenchay.

With the signing of these agreements, the lands were divided into two parts. Northern Azerbaijan was called Russian or Soviet Azerbaijan, and Southern Azerbaijan was called Iranian Azerbaijan. After that, the Russian Empire began to implement the Armenianization policy in the west part of Northern Azerbaijan. As a result, the Armenian state was founded for the first time in the west region. Thus, a new term – “Western Azerbaijan” has appeared in our history (https://anl.az/el/emb/Qerbi_Azerbaycan/tarixi.htm).

Western Azerbaijan is a very ancient region. Its natural-geographic conditions and cultural elements are very important. With this in mind, the purpose of the article is to study the cultural aspects of the region based on the historical and geographical overview.

The object of the article is West Azerbaijan, as well as the elements of its historical and geographical environment. The subject is the analysis of the region's historical-geographical conditions in the cultural sphere. During the research, sources such as books, newspapers and internet resources were widely used as a database.

1. HISTORY AND POPULATION OF WESTERN AZERBAIJAN

Historical sources and archeological explorations have proved that the lands of Azerbaijan were one of the oldest civilizations in the world. Caves such as Azikh, Damcili, Taglar, Gazma, Dashsalahli, as well as examples of agriculture, animal husbandry, and handicrafts belonging to the Paleolithic, Mesolithic, and Neolithic periods have been found in the area. Thus, one of the most ancient areas of the country's lands is Western Azerbaijan, which is considered its western region.

1.1. The history

West Azerbaijan is the oldest Turkish territory. As early as the b.c. II century, Azerbaijani Turks began to settle here. In the past, tribes such as Kimmer, Hun, Gugar, Sak, Gargar, Pecheneg, Shadili, Shirak, Kangar, Jinli, Oguz, Sabunchu, Afghan, Karapag, Mughan, Zangi, Kazakh, Khalaj, Turkmen, Ayrim and others lived in the region. This fact is confirmed by toponyms in the area: Khalaj, Shidli, Afshar, Gumru, etc. (Bayramov, 2015, p.8-12). Turkish tribes left their historical and cultural traces in these areas. In particular, some of the tribes settled around the Goycha lake.

In addition, some of the events in the “Kitabi-Dede Gorgud” heroic epics took place in this land. On the other hand, in the “Kitabi-Diyarbakriya” written by Abu Bakr Tehrani based on the instructions of Uzun Hasan of ruler Aggoyunlu, it is reported that Oghuz Khaga settled around Goycha lake and was buried here. In addition, Bayandur khagan and other Oghuz-Turkic commanders also operated, settled and were buried in the region of Western Azerbaijan. Such historical facts prove the antiquity of the region.

In the Middle Ages, the lands of Western Azerbaijan operated as part of states such as Atabay (Eldeniz), Garagoyunlu, Aggoyunlu, and Safavid.

Some changes were made in the administrative-territorial division of Western Azerbaijan under the rule of the Garagoyunlu, which appeared in the 15th century. Its north-west region is included in Karabakh, and its south-west region is included in Chukhursad province. In 1441, Jahanshah, the ruler of Garagoyunlu, allowed the Armenian-Gregorian church to be moved to Uchikilsa-Etchmiadzin. Thus, it had a significant negative impact on the position of the Albanian church in Iravan. It also directly influenced the religious and cultural thinking of the local population.

During the years of rule of the Aggoyunlu and Safavid states, the position of the administrative-territorial division of Chukhursad was kept as it was. However, according to the contract of Istanbul concluded as

a result of the Safavid-Ottoman wars in the 16th century, Chukhursad was given to the Ottomans. Thus, changes were made in Chukhursad and its territory was divided into Iravan and Nakhchivan provinces. At the beginning of the 17th century, the Safavid state took back the province of Iravan from the Ottomans.

In the 20s of the 18th century, Iravan again became part of the Ottomans. However, through the efforts of Nadir Shah Afshar, the province was recovered and included in his empire. It has been known from historical sources that after the murder of Nadir Shah, independent khanates were formed in the lands of Azerbaijan. One of them was the Iravan Khanate (1747-1828). The khanate included the lands of Agridag, Goycha lake, and the lands to the southwest from the Araz river. The capital of the khanate was the city of Iravan, and it had 15 districts. These include: Zangibasar, Goycha, Sharur, Kirkhbulag, Vedibasar, Talin, Seyidli-Akhsakhli, Surmeli, Sardarabad, Karpi, Garnibasar, Abaran, Derakand, Saatli, Darachichak. The statesmen who ruled the khanate are ranked according to the period of reign as follows:

1. Mehdi Khan
2. Muhammad Huseyn Khan
3. Khalil Khan
4. Huseynali Khan
5. Muhammad Huseyn Khan
6. Aligulu Khan Qajar
7. Hasan Khan Makulu
8. Mehdigulu Khan Qajar
9. Ahmad Khan Maragali
10. Huseyngulu Khan Qajar

At the end of 1827, Russia occupied the city of Iravan. On February 10, 1828, the contract of Turkmenchay was concluded, and Iravan became a part of Russia. It was after this that the process of Armenianization began in the territory of Iravan. First, The Tsarist Russia created the "Armenian province", then abolished it, turned Iravan into a governorate and was included in the Georgian-Imeret governorate. Then, the Iravan governorate was established in the area. The center was the city of Iravan. The Tsarist intended that Armenians should be the majority in the ethnic composition of the population in the governorate. According to the data of 1917, despite the genocide and deportations that took place in the area, the number of Azerbaijanis was 373,582 (33.35%), and the number of Armenians was 669,871 (59.8%).

In 1918, the Azerbaijan Democratic Republic, ceded approximately 9.5 thousand square kilometers of land around Iravan to the Armenians, and the Republic of Armenia (Ararat) was established there. At the end of 1920, Bolshevik Russia formed the Armenian Soviet Socialist Republic on the territory. After the collapse of the Union of Soviet Socialist Republics, that republic declared independence in September 1991. As a result, Armenians succeeded in creating their own state in the western lands of Azerbaijan (https://anl.az/el/emb/Qerbi_Azerbaijan/tarixi.htm).

1.2. The population

Armenian Azerbaijanis were forced to leave their lands as a result of the Nagorno-Karabakh conflict. According to the information provided by the Office of the United Nations High Commissioner for Refugees, Azerbaijanis currently live in Armenia. Most of them are Azerbaijani women married to Armenians who settled here, people who cannot leave the area due to old age and illness. Also, many of them have changed their names or hide their true identities to avoid being discriminated against. As a result of the policy of "Armenia without Turks" (1828-1989), more than 605 villages in the area no longer have Azerbaijanis living there. More than 1.5 million people were forced to leave their places, and more than 500 thousand Azerbaijanis were killed.

In general, the ethnic composition of the local population was diverse. The research of the Armenian-American historian George Burnutyan revealed that in the 19th century the population of the Iravan Khanate consisted of 100,000 people, and about 80% of them were Muslims (Azerbaijani, Persian, Kurdish), and 20% were Christians (Armenian). After the Khanate became part of Russia, a large number of Muslims were forced to leave and Armenians were moved to the territory.

According to the General Union population registration of 1926, a total of 83,181 Azerbaijanis settled in Armenia. In 1948-1950, another 100,000 Azerbaijanis were forced to leave the territory. In 1988-1991, 200,000 refugees were admitted to Azerbaijan, most of them were displaced Azerbaijanis from 22 districts of the region (https://anl.az/el/emb/Qerbi_Azerbaijan/azerbaycanlil.ar.htm).

In general, the process of deportation and resettlement of our compatriots from Western Azerbaijan began in the 18th century. The main deportation process in the 20th century can be divided into three stages:

- ✓ The first stage – 1905-1920 years;
- ✓ The second stage – 1948-1953 years;
- ✓ The third stage – 1988-1992 years

(https://anl.az/el/emb/Qerbi_Azerbaijan/merheleler.htm).

It is a well-known fact that these events that happened in Western Azerbaijan became an obstacle to the economic, social and cultural development of the region as a whole.

2. NATURAL AND GEOGRAPHICAL ENVIRONMENT OF WESTERN AZERBAIJAN

The nature and geographical conditions of Western Azerbaijan are quite significant. The region is very rich both in terms of climate and the diversity of the bio and zoo world. Although the names of most cities and geographical resources in the region have been changed.

2.1. The administrative-territorial division

The administrative-territorial division of Western Azerbaijan consisted of 10 uezd between 1920 and 1928, and 5 districts including Zangazur, Sevan, Lori, Iravan, Leninakan in 1929, and 36 districts in 1930. The current administrative-district division of the West Azerbaijan region is as follows:

- Shoreyel
- Nagorno Borchali
- Iravan
- Goycha
- Zargibasar
- Zangazur
- Kirkhbulaq
- Karbibasar
- Dilijan
- Daralayaz
- Sardarabad

(https://anl.az/el/emb/Qerbi_Azerbaijan/inzibati.htm).

During the USSR, “name change operations” were carried out in Western Azerbaijan based on the decrees of the Supreme Soviet of the Armenian SSR. According to the information, by August 1988, the names of 521 settlements were changed. The renaming operation in residences was carried out according to the mentioned rules:

- ❖ Names have been completely changed;
- ❖ Literally translated to Armenian;
- ❖ Changed under the cover of “internationalism”;
- ❖ It was replaced with a slight change, but with an Armenian name;

❖ Words before the name are written in Armenian.

At the same time, many Azerbaijani villages were removed from the list under the name of unification of the villages in the area: Ashagi Kilseh (Gufaark), Gamishli (Vardenis), Rahimabad (Masis), Agtala (Kamo).

In the years 1918-1987, 254 settlements were removed from the list by various methods. In the years 1948-1953, the names of more than 60 residences were changed. In 1978, 60 toponyms were changed in 23 districts, and in 1991, 90 localities were renamed (https://anl.az/el/emb/Qerbi_Azerbaijan/merheleler.htm).

2.2. The climatic conditions

Western Azerbaijan is located in the subtropical zone. Nevertheless, the area has different climate types based on its mountainous terrain. Its climatic conditions are influenced by the Black Sea, the Caspian Sea, Iran and the highlands of Asia Minor.

The annual duration of sunlight is 2000-2800 hours. The climate of the plains and the foothills is dry, and the climate is mild in the middle mountains. In the highlands, there is a cold climate and cool summer (Table 1).

Table 1.

Area	Average temperature in July	Average temperature in January	Precipitation	Vegetation period
Plains and foothills	24-26 °C; absolute max 42 °C	-5 °C	200-400 mm	6-7 months
Mountain plateaus and slopes (1400 m)	18-20 °C	-4 °C to -6 °C	500 mm	4-5 months
Mid-mountain parts	18 °C	-8 °C to -2 °C	600-800 mm	
High mountain areas (2000-3000 m)	10 °C-15 °C	-14 °C to -9 °C; absolute max -46 °C		

Western Azerbaijan region is divided into 6 climatic regions:

- The west part of Karabakh plateau;
 - Dry continental zone of Agridag-Arpachay parts;
 - The front mountainous basin of Agridag;
 - The north zone covering Dag Borshali, Pembak and Dilijan parts;
 - Highlands of the central region;
 - Areas higher than 3000 m above those zone
- (<https://westaz.org/az/qerbi-azerbaycan/erazi>; Yunusoglu, 2021, p.17).

2.3. The soil and landscape cover

The soil types of Western Azerbaijan are diverse: complex desert soils, takirs (hilly sandy areas), brown clay soils, brown stony soils, chestnut soils, brown soils, etc.

As an example of the mountains in the area: Alagöz mountain (Aragats), Garniyaryk mountain (Araler), Agchala mountain (Achkar), Ajdaha mountain (Ajdahak), Daveboynu (Ukhtasar), Aghmangan (Gegam), Daralayaz mountain (Vayotsdзор), Kután (Qutanasar), Aghdag (Spitakasar), Basarkechar mountain range (Vardenis), Gargar (Tskhuk), Tej-Ahmed/Tej (Tej-ler) and others

(<https://westaz.org/az/qerbi-azerbaycan/erazi>; https://anl.az/el/emb/Qerbi_Azerbaijan/toponimler.html).

2.4. The flora and fauna

At present, only 11% of Western Azerbaijan is forest. More than 250 plant species grow in the forests. 81.3% of the forests are occupied by broad-leaved trees such as oak, hemlock, and beech, and about 8% are occupied by pines. In general, steppes and pastures occupy 18%-30% of the area in the region.

The flora of the region is very diverse: linden, oak, pine, juniper, ash, holly, beech, maple, poplar, fig, grape, pear, wild apple, peach, walnut, apricot, pomegranate, berries, wormwood, astragalus, acantholimon, tragacanth, frigganoid etc.

The fauna of the region includes 450 vertebrates, more than 10 thousand invertebrates, 304 birds, 24 fish, 20 snakes and other species. Examples of these are: Syrian bear, roe deer, Ussuri spotted deer, fox, forest cat, leopard, lynx, viper, arachnid-scorpion, Caucasian viper, jungle cat, wild boar, snake eagle, seagull, jackal, swamp harrier, mountain mole rat, Asia Minor ground squirrel, Asia Minor rat, raccoon dog, woodpecker, partridge, sparrow, woodpecker, vulture, woodcock, khramuli, ilgaba, alpine finch, imperial eagle, Caspian

snow grouse, barbel, koga, bearded eagle etc. (<https://westaz.org/az/qerbi-azerbaycan/erazi>).

2.5. The hydrological network

The hydrological network of the region includes resources such as glaciers, rivers, lakes, underground water basins, and wetlands. A total of 9,500 rivers flow through the territory of Western Azerbaijan. The largest of the rivers is Araz. There are around 100 lakes in the region. Goycha lake (1276.6 sq. km), which is considered the largest lake in the Caucasus, is located on its territory. In general, the hydrological network of Western Azerbaijan can be systematized as follows:

♣ Rivers: Araz (Araks), Garni (Azad), Bazarchai (Vorotan), Aghstafachay (Agstev), Zangi (Hrazdan), Arpachay (Akhuryan), Ayanzur (Aghavnadzor), Garanlig (Martuni), Gorus (Goris), Elayaz (Yegegisi), Bastichay (Tsva), Jalaloglu (Dzoraget), Baligly (Dzknaget), Basarkecher (Vardenis), Tarsachay (Getik), Tona (Debed), Karasu (Sevcur), Okchuchay (Vokchi);

♣ Lakes: Goycha (Sevan), Dibsiz (Achkar Lake), Arpa (Arpi), Aygir (Aygir Lake), Karagol (Kari Lake), Aydın (Parz Lake), Goygol (Gosh Lake), etc. .

Goycha lake fascinates people with its blue waters. Due to its tectonic origin, this lake covers an area of 2776 square kilometers. The lake connects two main parts, Big Goycha and Little Goycha. About 2,000 springs boil in the bed of the lake and mix with the water of the lake and help to clean the water. Since 1923, the water level of the lake has decreased due to the use of water in irrigation agriculture. In the 1960s, plants were planted around the lake with the help of muslim-turkish villagers living in Basarkecher, Chambarak, Pambak and Kavar. With this, this problem has been avoided. In 2004, a religious academy was opened and a church was even built by the reactionary Hay Church on the shore of Goycha lake (https://anl.az/el/emb/Qerbi_Azerbaycan/toponimler.html; https://anl.az/el/emb/Qerbi_Azerbaycan/co-grafiya.htm).

The diversity of natural resources in the region indicates the richness of natural culture of Western Azerbaijan. It is clear that nature itself has a special role for the development of the cultural environment and aesthetic encounter.

CONCLUSION

First of all, it should be noted that the cultural phenomenon is related to many sciences. Also, integration with history and geographical sciences is developing.

It is in the first part of the article that the historical periods and geographical environment of Western Azerbaijan were investigated. As it is known from the sources, the fate of the region has been quite difficult. It faced numerous occupations and genocides. Russia's Armenianization policy in the region, the formation of the Republic of Armenia in the region, as well as the

process of deportation of the local population have caused to the cultural decline of the area. This was the economic and moral collapse of Western Azerbaijan.

In the second part of the article, the natural-geographical conditions of Western Azerbaijan are described. In this part, information about its administrative-territorial division, landscape, flora and fauna is provided, toponyms changed after the occupation are presented. Of course, the richness of natural and cultural resources helps the development of culture.

As a result, we looked at the historical and geographical overview of Western Azerbaijan. This, in turn, is one of the factors that play an important role in the development of culture.

ACKNOWLEDGMENT

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TECHNICAL SCIENCES

NUMERICAL SIMULATION OF CONVECTIVE HEAT TRANSFER IN GLASS UNITS

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ЧИСЕЛЬНЕ МОДЕЛЮВАННЯ КОНВЕКТИВНОГО ТЕПЛООБМІНУ В СКЛОПАКЕТАХ

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Abstract

The article is devoted to the study of convective heat exchange in two-chamber glass units. The mathematical model contains heat conduction equations for glass and convective heat transfer equations in approximate Boussinesq for double-glazed chambers. A two-dimensional problem in conjugate formulation was considered. Numerical implementation of the model was performed using the finite element method. As a result of numerical experiments, the thermophysical characteristics of double-glazed windows were calculated for different temperature regimes and geometric parameters. Visualization of the complex structure of convective flows and non-homogeneous temperature distribution in the double-glazed chambers was obtained. Calculations were carried out for different fillers of double-glazed chambers, namely air, argon, and krypton.

Анотація

Стаття присвячена дослідженню конвективного теплообміну в двокамерних склопакетах. Математична модель містить рівняння теплопровідності для скла та рівняння конвективного теплообміну в наближенні Бусінеска для камер склопакету. Розглядалась двовимірна задача в спряженій постановці. Чисельна реалізація моделі виконувалась методом скінчених елементів. В результаті проведених чисельних експериментів обраховані теплофізичні характеристики склопакетів для різних температурних режимів та різних геометричних параметрів. Отримана візуалізація складної структури конвективних потоків та неоднорідного розподілу температури в камерах склопакету. Розрахунки проводились для різних наповнювачів камер склопакету, а саме – повітря, аргон, криптон.

Keywords: glass units, heat transfer, numerical simulation, finite element method.

Ключові слова: склопакет, теплообмін, чисельне моделювання, метод скінчених елементів.

Проблеми енергозбереження останнім часом набули особливого значення. Суттєва доля втрат теплової енергії в житлових приміщеннях відбувається через вікна. Зменшити втрати тепла можна завдяки використанню якісних склопакетів. На ринку представлено широкий вибір подібної продукції з різними конструктивними параметрами – однокамерні, двокамерні, з енергозберігаючим покриттям, з наповненням інертними газами або повітрям, з різними зазорами та товщиною скла. Теплопередача через склопакет відбувається за рахунок випромінювання, конвекції та теплопровідності. Впливати на теплоізоляційні властивості склопакета можуть також інші фактори, такі як конденсація вологи, прозорість скла та ін. Для оцінки енергозберігаючих властивостей склопакетів зазвичай використовують одновимірні математичні моделі, які не враховують фактори конвективного руху повітря або газу в камерах та неоднорідний розподіл температур. Використання чисельних методів дозволяє використовувати більш складні багатовимірні математичні моделі,

які враховують більшість факторів, що впливають на процес теплопередачі через склопакет. В роботі [1] представлені результати чисельного моделювання спряженої задачі теплообміну в однокамерному склопакеті з урахуванням його деформації під дією зовнішнього тиску. Подібні задачі розглядались в роботах [2-4]. В роботі [5] чисельно аналізується сполучена теплопередача через вікно з двокамерним склопакетом за допомогою методу кінцевих різниць. Метою дослідження є визначення оптимальної товщини повітряного прошарку між двома склопакетами для різних кліматичних умов. В роботі [6] проведено чисельне дослідження вільної конвекції у вікні з двокамерним склопакетом із плісированою тканинною шторкою. В роботі [7] чисельно досліджено двокамерний склопакет із вбудованими жалюзі, і для подальшої оцінки розглядається єдиний зимовий режим у приміщенні.

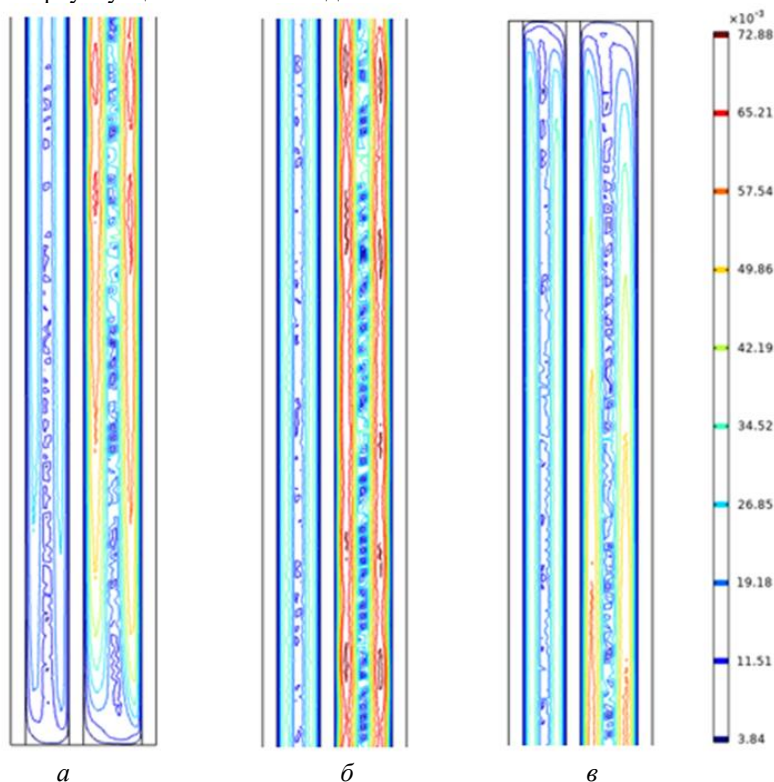
В роботі розглядається двовимірний мультифізична модель склопакету. Досліджується вплив фа-

кторів конвекції в камерах склопакету на теплоізоляційні властивості. Фактор випромінювання не розглядається. Процес теплообміну описується дво-вимірними диференційними рівняннями теплопровідності для скла та рівняннями конвективного теплообміну в камерах між шарами скла. Задача розглядається в спряженій постановці. Враховуючи нелінійний характер і складність рівнянь задача допускає лише чисельний розв'язок. Для чисельної реалізації моделі використовувався програмний комплекс COMSOL Multiphysics. Задача вирішувалась за допомогою метода скінчених елементів. Для зовнішніх поверхонь склопакету використовувались граничні умови конвективного теплообміну для вертикальних поверхонь, на торцевих поверхнях ставились умови теплоізоляції. Для опису конвективного руху в камерах склопакету використовувались рівняння вільної конвекції в наближенні Бусінеска. Побудова геометрії та тріангуляція розрахункової області виконувались за допомогою вбудованих в COMSOL Multiphysics інструментів. Задача вирішувалась в квазістаціонарній постановці. Ітерації проводились до повного установлення. В деяких режимах не вдавалось отримати повне установлення ітераційного процесу у зв'язку з наявністю конвективних флуктуацій. В таких випадках

розглядалась нестационарна постановка задачі, а час розрахунку визначався стабілізацією інтегральних характеристик процесу теплообміну.

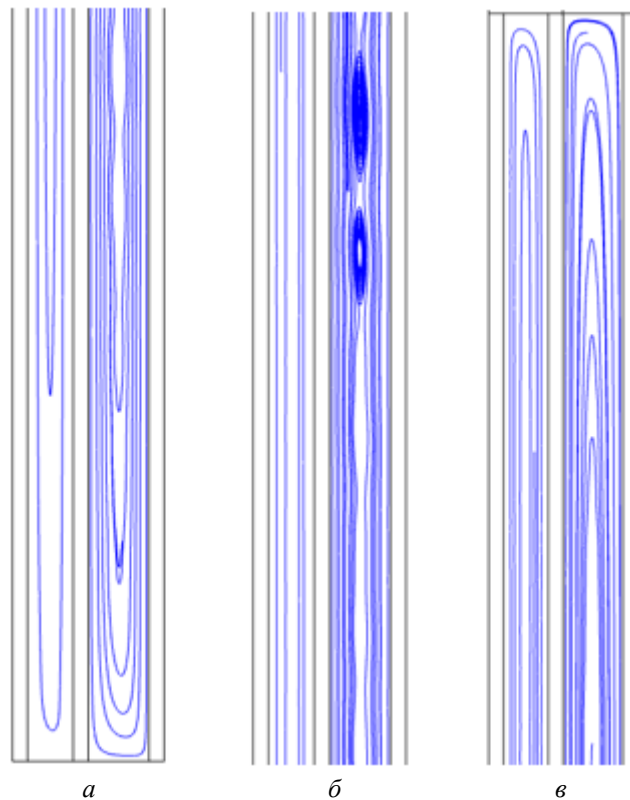
Проведена серія чисельних експериментів для різних геометричних параметрів склопакетів, різних зовнішніх умов (від -20°C до 0°C), різних наповнювачів (аргон, криптон, повітря), а також комбінації наповнювачів.

В якості прикладу наведено результати розрахунків для двокамерного склопакету товщиною 40 мм. Висота та ширина склопакету становлять відповідно 1.3 м та 1 м. Товщина скла 4 мм, а ширина камер, заповнених повітрям $h_1=12$ мм та $h_2=16$ мм (рис.1). Зовнішня температура -20°C , внутрішня $+20^{\circ}\text{C}$. Як бачимо, в камерах склопакета формується складна структура конвективних потоків. У внутрішній камері спостерігається більш інтенсивний конвективний рух в порівнянні з зовнішньою камерою. Максимальні швидкості локалізуються в центральному фрагменті склопакету. В приграничних шарах біля поверхні скла формуються висхідний та низхідний потоки, а в центральній області спостерігаються циркуляційні комірки (рис.2).



а – нижній фрагмент; б – середній фрагмент; в – верхній фрагмент.

Рис. 1 – Розподіл швидкостей (ізоахи) конвективних потоків в камерах склопакета.

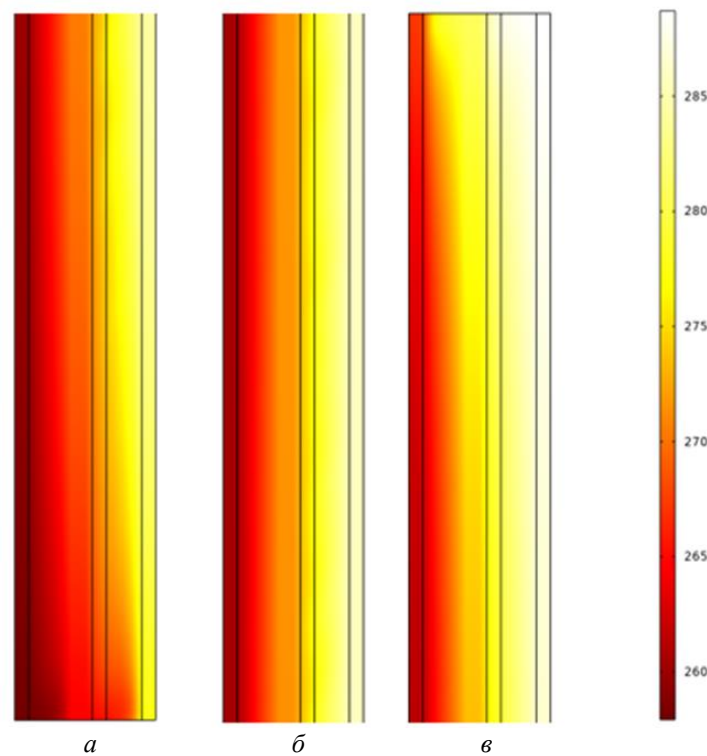


а – нижній фрагмент; б – середній фрагмент; в – верхній фрагмент.

Рис. 2 – Лінії току в камерах склопакета.

На рис.3 наведено розподіл температури для різних фрагментів склопакету. Неоднорідний розподіл температури обумовлено наявністю конвективних потоків в камерах склопакету за рахунок те-

мпературних градієнтів. В верхній частині склопакету формується зона підвищеної температури в порівнянні з нижньою частиною. В центральній області розподіл температури по ширині склопакету майже незмінний.



а – нижній фрагмент; б – середній фрагмент; в – верхній фрагмент.

Рис. 3 – Розподіл температури в двокамерному склопакеті.

COMSOL Multiphysics має інструменти, які дозволяють обчислювати інтегральні теплофізичні характеристики, локальний та загальний теплові потоки, тепловий опір, визначати максимальну, мінімальну, середню температуру. На рис. 4 наведено загальні витрати тепла через площину склопакету в залежності від співвідношення розмірів та видів наповнення повітряних камер. У всіх випадках сума розмірів зовнішнього зазору h_1 та внутрішнього h_2 складала 28 мм. Значення $h_1=0$ мм та $h_1=28$ мм по суті відповідають варіантам однокамерних склопакетів з різною товщиною скла. Підтверджена передбачувана ефективність теплоізоляційних властивостей склопакетів з інертними газами. Як показують розрахунки, товщина скла слабо впливає на загальну теплоізоляцію, оскільки коефіцієнт теплопровідності скла досить високий. Більш впливовими факторами, які визначають тепловий опір, є кількість камер склопакету, наповнення камер інертними газами замість повітря, збільшення товщини склопакету. Але реалізація цих конструктивних особливостей суттєво збільшує вартість продукту.

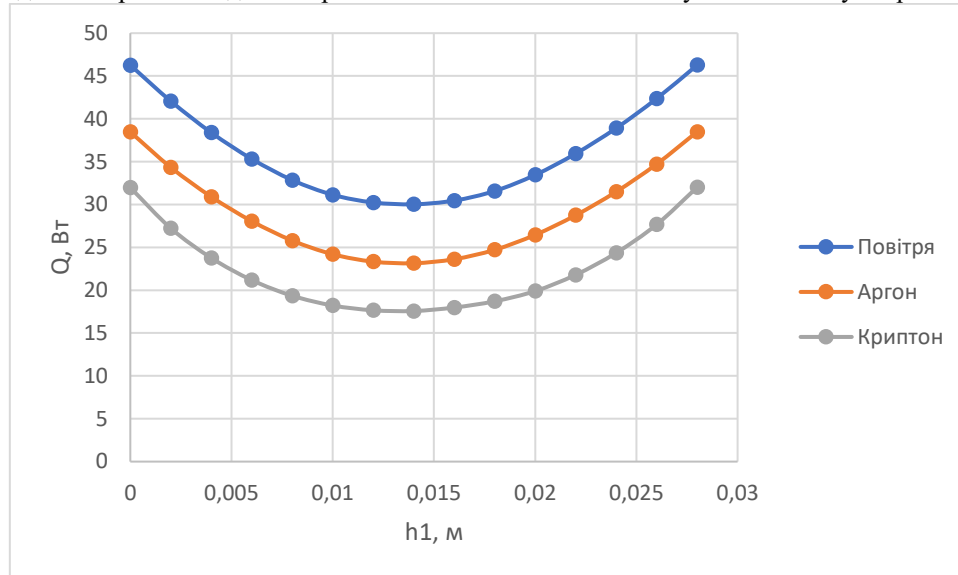


Рис. 4 – Витрати тепла через площину склопакету в залежності від ширини зовнішньої камери

На рис. 5 наведено розрахунок теплового опору склопакету в залежності від ширини зовнішньої камери h_1 . Як бачимо, найменші втрати тепла відповідають випадку, коли $h_1=h_2$.

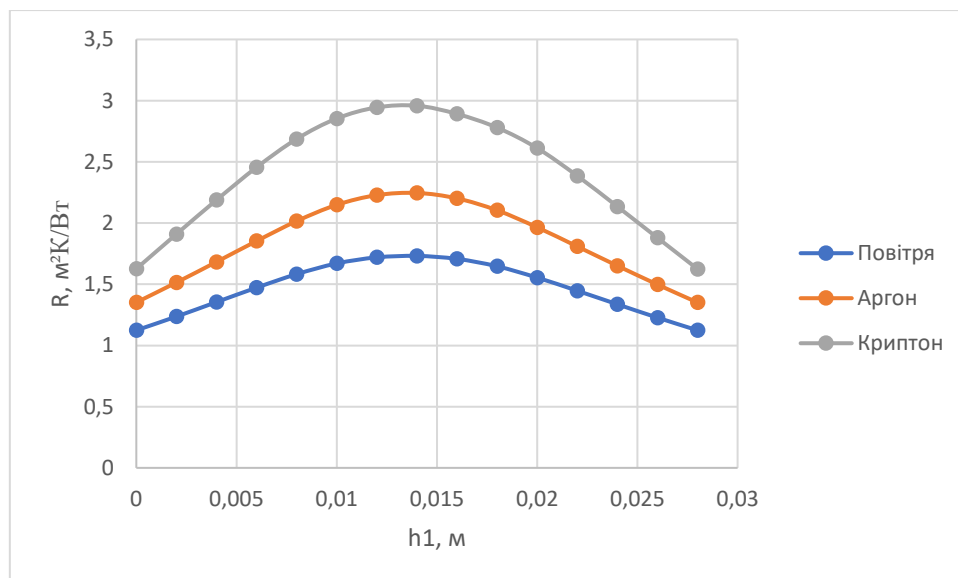


Рис. 5 – Тепловий опір склопакету в залежності від ширини зовнішньої камери h_1 та виду наповнювача.

На рис. 6 наведено розрахунок теплового опору склопакету в залежності від зовнішньої температури та ширини камери h_1 . Температура в середині приміщення залишалась на рівні 20°C. Для розрахунку використовувалась різниця температур в середині приміщення та зовні. Враховуючи кон-

вективний теплообмін, температури зовнішніх поверхонь склопакету будуть відрізнятися від температур оточуючого середовища. То ж, якщо використовувати для розрахунку різницю зовнішніх температур поверхонь склопакету, результати будуть відрізнятися від наведених.

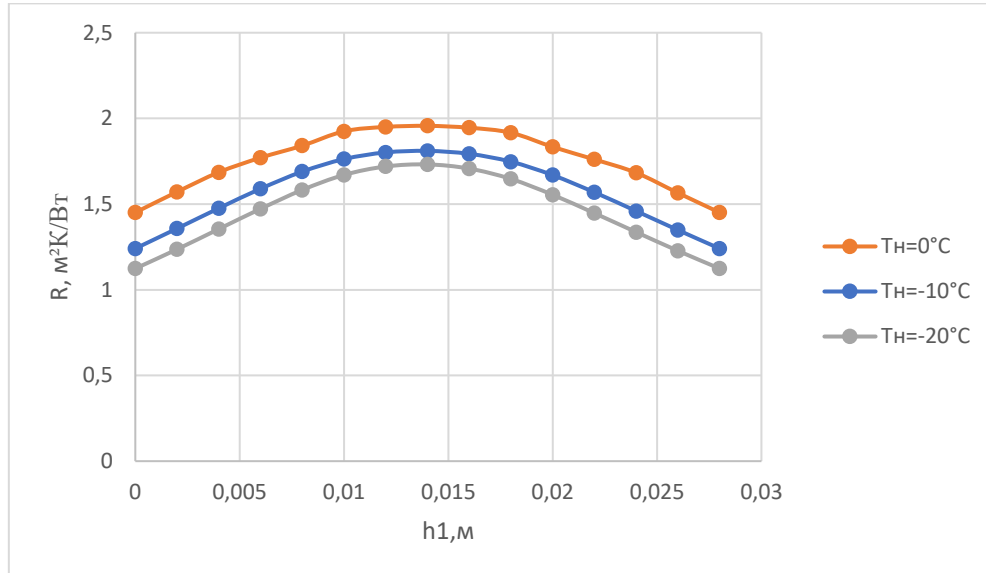


Рис. 6 – Тепловий опір склопакету з повітряним наповненням камер в залежності від зовнішньої температури T_n та ширини камери h_1 .

Представлена модель дозволяє оцінювати теплофізичні характеристики склопакетів довільної геометрії, з різною кількістю камер, різною товщиною скла, а також для різних наповнювачів та ширини камер. Результати розрахунків дозволяють обґрунтовано обирати варіанти склопакетів для певних кліматичних умов.

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THE CURRENT STATE OF BLOCKCHAIN TECHNOLOGY: PROBLEMS AND DIRECTION OF DEVELOPMENT

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СОВРЕМЕННОЕ СОСТОЯНИЕ ТЕХНОЛОГИИ БЛОКЧЕЙНА: ПРОБЛЕМЫ И НАПРАВЛЕНИЕ РАЗВИТИЯ

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Abstract

The article analyzes the most popular and productive blockchain technologies, which made it possible to identify and summarize their advantages and disadvantages from the point of view of technical implementation. Promising directions for improving blockchain technologies have been identified: the use of directed acyclic graphs, sharding technology, as well as improving the consensus algorithm.

Аннотация

В статье проведен анализ наиболее популярных и производительных блокчейн-технологий, который позволил выявить и обобщить их преимущества и недостатки с точки зрения технической реализации. Определены перспективные направления усовершенствования блокчейн-технологий: использование направленных ациклических графов, технологию шардинга, а также усовершенствование алгоритма консенсуса.

Keywords: blockchain technology, sharding, consensus algorithms, decentralization, security, scalability.

Ключевые слова: технология блокчейна, шардинг, алгоритм консенсуса, децентрализация, безопасность, масштабируемость.

Введение. Стремительная информатизация современного общества, изменение взглядов человечества на организацию экономических, политических и социальных процессов, а также развитие вычислительной техники приводит к значительному увеличению объема информации, которую необходимо обрабатывать и анализировать в реальном масштабе времени. Этот процесс требует от вычислительных средств высокого быстродействия, больших объемов как оперативной, так и дисковой памяти.

В современном мире все большее распространение получают распределенные системы вычисления, облачные технологии, децентрализованное хранение информации. Однако при всех их преимуществах связанных с повышением быстродействия возникают и новые проблемы. В основном они касаются угроз безопасности информации циркулирующей в распределенной сети, их целостности и конфиденциальности. Кроме того, в аспекте обработки данных возникают сложности с процессом

масштабирования и реализации алгоритмов обработки повышенной сложности. Технологии распределенных вычислений и децентрализованного хранения информации были представлены еще в 90-х годах. Тем не менее понятие “блокчейн” стали использовать недавно, после того как Сатоши Накамото показал, как эти технологии могут быть использованы для устройства новой финансовой системы [1]. Так, в 2008 году появился биткоин, что положило начало истории развития блокчейна.

В настоящее время под терминами “технология блокчейн” (blockchain) или “технология распределенного реестра” (distributed ledger technology – DLT) понимают технологический протокол, который позволяет осуществлять обмен данными напрямую между различными договаривающимися сторонами внутри сети без необходимости в посредниках [2,3].

Анализ финансовых вложений в сферу информационных технологий за последнее время показал стремительный рост и особенно это касается разра-

боток, направленных на развитие блокчейн технологий. Рынок блокчейн технологий является относительно новым и растущим [4]. Так, согласно [5] за 2017 год, общие расходы разных стран на решения этих вопросов составили 945 млн. долл. США. В 2018 году объем рынка блокчейн увеличился до 1,5 млрд. долл. США. К 2024 году прогнозируется рост объемов рынка до 19 млрд. долл. США [5, 6]

Таким образом, анализ современного состояния развития технологии блокчейна и определения перспективных путей ее развития является актуальной задачей на современном этапе.

Постановка задачи. В настоящее время технология блокчейн развивается как обособленная технология, которая может применяться и за рамками систем криптовалют. Согласно отчету международной исследовательской и консалтинговой компании IDC, на начало 2021 года блокчейн находит широкое применение трансграничных платежей и расчетах (15,9%), отслеживании партий товаров (10,7%), финансировании торговых операций (10%), управлении активами (8,8%), управлении аутентификацией (7,6%) [5,6].

Применение данной технологии в различных областях цифровой экономике и бизнесе за рубежом становится все более перспективным. На развитии этих аспектов обращают пристальное внимание страны Европейского союза. Так Европейский совет подчеркивает, что развитие “цифровой” экономики является стратегическим направлением, определяющим конкурентоспособность стран на мировой арене [7, 8].

В рамках документов [9–11] были определены национальные приоритеты на долгосрочный период, а именно переход к цифровой экономике и внедрение новых форматов государственного управления. В [12] указывается, что своевременное создания условий для внедрения различных цифровых технологий является необходимым залогом дальнейшего развития государства. Это, прежде всего, формирование информационной инфраструктуры, информационной безопасности, нормативно-правовое регулирование, формирование исследовательских компетенций и технологических основ, подготовка кадров, образование.

Для цифровой экономики условно можно выделить следующие области применения блокчейн-технологий [13]:

- в области финансов: транзакции на основе криптовалют (например, внедрение цифровых платежей на основе эфира, биткоин);
- в области экономики, рынков и интернета вещей: смарт-контракты (например, применение технологии работы с акциями, облигациями, складными, фьючерсами, правовыми титулами, активами и т.д.);
- в области управления: организация государственного управления, науки, образования, здравоохранения и др. (применение технологии вне рамок финансовых транзакций).

О перспективности технологии блокчейна существуют различные противоречивые мнения экспертов [14,15]. Несмотря на некоторые успешные

попытки внедрения технологии блокчейна, она пока остается экспериментальной со всеми сопутствующими рисками, проблемами внедрения и эксплуатации [16]. Преимущества и недостатки технологии блокчейна приведены в многочисленных работах ряда авторов [2,4,8,17–20].

Однако, экспертное сообщество обращает внимание на недостаточную изученность таких аспектов применения блокчейн как информационная безопасность, достоверность данных, быстродействие, эффективность протокола взаимодействия узлов (выработка консенсуса) в сети блокчейн [21].

Таким образом, анализ работ в области применения блокчейна выявил необходимость проведения исследований направленных на устранения “белых пятен”, мешающих дальнейшему развитию технологии блокчейна с технической точки зрения.

Цель статьи – определение перспективных направлений развития и усовершенствования блокчейн-технологий путем анализа их технических возможностей по устранению существующих недостатков.

Для достижения цели были поставлены следующие задачи:

1. провести анализ существующих блокчейн-технологий, их преимуществ и недостатков с точки зрения технической реализации;
2. определение перспективных направлений усовершенствования блокчейн-технологий.

Анализ существующих блокчейн-технологий. Будем рассматривать блокчейн, именно как обособленную технологию с технической точки зрения, анализируя ее преимущества и недостатки.

Компанией Deloitte был составлен рейтинг городов по числу проектов, реализуемых на блокчейне [6]. Возглавляет список Сан-Франциско, где разрабатываются различные программные решения для организации работы бирж, интерфейсы для работы блокчейнов, платежные инструменты для криптовалют и др. Лондонские специалисты активно занимаются цифровой идентификацией и смарт-контрактами. Специалисты Нью-Йорка разрабатывают проекты, связанные с решением задач в финансовой сфере (сервисы финансовых услуг). Китайские проекты, которые разрабатываются в Пекине и Шанхае, связаны с криптовалютами и биржами криптовалют. Особый акцент делается на масштабируемость проектов и их производительность [22].

По мнению аналитиков международной консалтинговой компании McKinsey [23], реальный прогресс внедрения блокчейн-технологий в экономику незначителен и не оправдывает огромных вложений денежных средств, что обосновано возникшими техническими трудностями.

На сегодняшний день существует более 10 тыс различных блокчейнов, которые являются либо публичными (открытый код) либо частными. Рассмотрим некоторые характеристики существующих популярных и быстрых блокчейнов (табл.1):

1. Bitcoin. Прошло 12 лет с момента запуска Bitcoin, однако основная проблема быстродействия так и не была решена. Быстродействие данного

блокчейн составляет всего лишь около 7 транзакций в секунду (Transactions-per-second (TPS)), частота обновления блоков составляет 1 раз в 10 минут. Алгоритмом консенсуса, используемого в сети, является алгоритм типа Proof-of-Work (PoW) [19].

2. Ethereum. Платформа блокчейна предназначена для создания децентрализованных онлайн-сервисов, работающих на базе смарт-контрактов. Реализована как единая децентрализованная виртуальная машина. Разработчиком Ethereum Бутериным заявлена скорость – 20 TPS. 15 сентября 2022 года был осуществлен переход с PoW протокола на PoS протокол, что позволило увеличить пропускную способность сети, а также уменьшить затраты на обслуживание. Кроме того, на данный момент

осуществляется запуск шардинга в сети, что также позволит увеличить число транзакций [24,25].

3. Minter. Блокчейн представлен, как DeFi-платформа со смарт-контрактами и кросс-чейн ликвидностью с использованием широкого набора SDK и API-инструментов. За разработку данного блокчейна отвечает команда приблизительно из 20 российских специалистов. Используемый протокол консенсуса – Delegated Proof-of-Stake (DPoS), идея которого заключается в выборе валидаторов путем голосования. В будущем запланирована интеграция с TON, что позволит участникам производить обмен токенов этих сетей и использовать смарт-контракты. Архитектура Minter позволяет поддерживать транзакции вне сети. Скорость формирования блока составляет 1 раз в течении 5 секунд [26].

Таблица 1

Характеристики существующих блокчейнов

Название блокчейн технологий	TPS	Децентрализация	Шардинг	Масштабируемость	Смарт-контракт	Частота обновления блоков	Доступность	Поддержка языков программирования	Наличие виртуальной машины	Многоуровневость платформы	Принцип верификации
Bitcoin	7-10	да	нет	да	базовые принципы	1 раз в 7-10 минут	Открытый код	C++, Java, JS, Python	-	-	PoW
Ethereum	15-30	да	нет	да	да	1 раз в 12-15 секунд	Открытый код	Python, Go, Mutan, LLL, JS, Solidity, Ruby, Rust	да	да	PoW/ PoS
Minter	2000	да	да	да	да	1 раз в 5 секунд	Открытый код	Goland	-	да	DPoS
Cardano	5000	да	нет	-	да	1 раз в 9 минут	Открытый код	Haskell, Solidity	-	да	PoS
QTUM	10000	да	нет	да	да	-	Открытый код	C++, Solidity	да	да	MPoS
Solana	50000	да	нет	да	да	1 раз в 400 микросекунд	Открытый код	Rust	-	да	PoS/ PoH
Everscale	68000	да	да	да	да	1 раз в 500 микросекунд	Открытый код	C++, Solidity, FIFT, Rust	да	да	PoS
Near	-	да	да	да	да	1 раз в 2 секунды	Открытый код	C++, JS, Python, Rust	-	да	TPoS
Neo		да	-	да	да	-	Открытый код	C#, F#, Java, Python,	-	-	BFT

4. Cardano. Данный блокчейн имеет много общего с Ethereum, так этот проект был учрежден Ч. Хоскинсоном. Это блокчейн платформа для криптовалюты под названием ADA. Cardano может обрабатывать от 50 до 250 TPS. По его словам, добавление технологии масштабирования блокчейна путем создания параллельной сети с двусторонней привязкой в будущем позволит достичь более 5000 TPS. Система ориентирована на запуск смарт-контрактов,

децентрализованных приложений и многопартийных вычислений. Высокая степень отказоустойчивости [27].

5. QTUM. Это децентрализованный блокчейн, которая сочетает в себе возможности смарт-контрактов Ethereum с концепцией Bitcoin. Используется механизм консенсуса Mutualized PoS (MPoS), защищающий сеть от атак мошеннических контрактов. В августе 2020 разработчики QTUM протестировали эффективность своего блокчейна на

виртуальном сервере Amazon EC2 и пришли к выводу, что QTUM способен обрабатывать более 10 000 TPS [28].

6. Solana. Это блокчейн третьего поколения, предназначенный для поддержки масштабируемых децентрализованных приложений (DApps) и смарт-контрактов. Он имеет максимальную пропускную способность более 50 000 TPS и период формирования блока всего 400 мс. Solana использует гибридный алгоритм консенсуса, который сочетает Proof-of-History (PoH) с PoS [29].

7. Everscale. Блокчейн с открытым исходным кодом. Платформа Everscale состоит из подмножества рабочих блокчейнов (воркчейнов), их шардчейнов, и их блоков, что синхронизируются с основным для актуализации распределенного реестра. Существует вертикальное и горизонтальное масштабирование, что позволило достичь скорости 68000 TPS в реальных условиях [30]. В основной сети на данный момент запущен только 1 воркчейн, в связи с отсутствием необходимости содержать большее количество. Блокчейн Everscale использует для организации своей работы PoS протокол.

8. Near. Это блокчейн первого уровня, использующий уникальную технологию шардинга для достижения масштабируемости. Он запущен был в

2020 году как децентрализованная облачная инфраструктура для размещения децентрализованных приложений (DApps). Существует кроссчейн-взаимодействие для организации многоуровневой платформы. Используемый протокол консенсуса – Thresholded Proof-of-Stake (TPoS), напоминающий аукцион для установления минимального порога для валидаторов. Однако на данный момент найти данные по быстродействию данного блокчейна практически невозможно, но теоретически Near позволит обрабатывать миллионы транзакций в секунду [31].

9. Neo. Блокчейн является азиатским некоммерческим проектом, целью которого является создание “умной экономики” [32]. Используемый протокол консенсуса – Byzantine Fault Tolerance (BFT)

Анализ функционирования вышеперечисленных современных блокчейнов и их характеристик подтвердил, что для повышения скорости обработки и финализации транзакций сетью (масштабируемость) блокчейн должен пожертвовать либо децентрализацией, либо безопасностью (рис. 1).

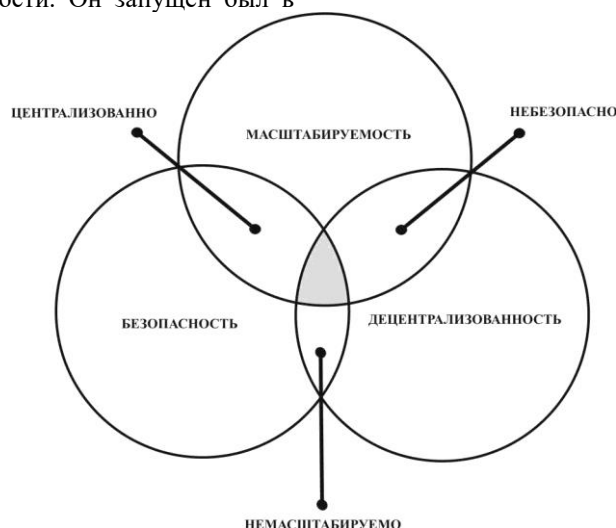


Рисунок 1 – Аспекты трилеммы блокчейна

Таким образом, возникает необходимость решения проблемы достижения оптимизации аспектов трилеммы масштабируемости, предложенной Бутериным [24–26]: децентрализация, безопасность и масштабируемость.

Перспективные пути совершенствования блокчейн-технологий. Для решения поставленной проблемы необходимо такая организация функционирования блокчейна, которая обеспечит ее безопасное устройство, и нагрузка на узлы системы будет ограничена.

Одним из вариантов решения проблемы масштабирования является использование подходов, основанных на направленных ациклических графах. Направленные ациклические графы представляет собой графическую структуру, не имеющую циклов, при этом все ребра связывают узлы сети (ноды) в одном направлении. Это позволит постро-

ить архитектуру сети, используя последовательность вершин в топологическом порядке. Однако данная технология не является блокчейном в чистом виде, так как контроль над передачей информации не требуют доказательства выполнения работы, наличия майнеров и наличия блоков. Направленные ациклические графы представляет собой не “цепь”, а “дерево”, где каждая операция подтверждает предыдущие. Технология на сегодняшний день находится на этапе развития и обладает большим потенциалом [16].

Не меньшим потенциалом обладает и использование шардинга, под которым будем понимать горизонтальное разделение данных, метод разделения и хранения одного набора данных в виде множества различных баз данных, возможно находящихся в различных местах. По сути блокчейн – это индивидуальные сервера (ноды), каждая из кото-

рых имеет свою базу данных, которые могут пересекаться между собой, а вместе объединяются в одну большую базу. Для блокчейна шардинг рассматривается как разделение сети на сегменты (шарды). В каждом шарде содержится информация о наборе смарт-контрактов и информации, которые способны функционировать внутри сегмента и между сегментами. В каждом шарде валидируют свои ноды (валидаторы), проверяющие и подтверждающие транзакции и сообщения, когда в обычной схеме каждый валидатор может проверять любую транзакцию и любое сообщение во всей сети.

Такой подход позволяет разделить сеть на несколько более управляемых и не таких больших сегментов, что дает возможность масштабировать сеть и увеличить ее пропускную способность. Классический блокчейн состоит из огромного количества валидаторов и нод, которые исполняют смарт-контракты, а также на которых функционируют децентрализованные приложения, исходя из парадигмы последовательного выполнения каждой транзакции. То есть все валидаторы и ноды обрабатывают каждую транзакцию в сети. Из-за этого прохождение транзакцией всех этапов верификации занимает большое количество времени и чем больше транзакций в сети, тем больше памяти они занимают. Также при появлении узла в сети возникает ситуация, когда новому участнику приходится синхронизировать всю обработанную ранее информацию и не всегда приносит прирост эффективности работы, так как цепочка верификации просто становится длиннее.

Сама идея шардинга заключается в том, чтобы последовательное исполнение транзакций распределить между различными сегментами (шардами) и чтобы каждый шард выступал в роли маленького блокчейна. Валидаторы в них обрабатывали внутренние транзакции и только их. Но при этом сохранить взаимосвязь этих сегментов, для полноценной работы основного целого блокчейна. Как показала практика, данный подход дает возможное решение проблемы масштабирования сети, так как уменьшение нагрузки дает увеличение пропускной способности сети. Однако коммуникация и безопасность являются главными проблемами шардинга. При разделении блокчейна на изолированные сегменты, каждый шард становится отдельной сетью. Пользователи из одного сегмента сети не смогут создавать транзакции с пользователями и приложениями другого сегмента сети, не используя дополнительные методики коммуникации.

В разбитой на сегменты сети потенциально существует опасность мошенничества, так как злоумышленникам проще создать некорректные транзакции в одном шарде, поскольку её будет валидировать меньшее количество нод (стандартная атака "51%"). Таким образом, злоумышленники могут захватить сегмент сети, который будет влиять на работу всего блокчейна. В связи с этим было предложено рандомизировать выбор валидаторов внутри шарды и внутри всего блокчейна, что снижает вероятность захвата сегмента и использование парадигмы бесконечного шардирования.

На данный момент остаются нерешенными некоторые вопросы безопасности и эффективности шардинга, что оставляет технологию относительно сырой для использования в промышленных масштабах.

Таким образом, основными преимуществами применения технологии шардинга является повышение быстродействия функционирования блокчейна, снижение нагрузки на отдельные ноды сети и снижение технических требований к валидаторам. К недостаткам можно отнести возникновение необходимости в дополнительных методиках коммуникации шардов между собой и повышение опасности мошенничества.

Важным аспектом развития технологии блокчейна является усовершенствование алгоритма консенсуса, который позволит оптимизировать работу и повысить защищенность сети блокчейн особенно с технологией шардинга. Под алгоритмом консенсуса будем понимать метод, с помощью которого распределенные узлы в сети достигают согласия относительно элемента данных [26]. Блокчейн-системы не в состоянии функционировать без выполнения формализованных правил поведения, которым следует все участники сети. Одни алгоритмы позволяют строить надежные децентрализованные системы, другие – блокчейны с большой пропускной способностью и масштабируемостью.

Первым алгоритмом консенсуса, использующимся в блокчейн-системах, и самым распространенным на данный момент является Proof-of-Work (PoW). В основе алгоритма PoW лежит функция, для вычисления которой необходимо затратить много машинного времени и ресурсов, а вот результат вычислений просто проверить. Это могут быть такие функции как хеширование частичной инверсии, функции, базирующие на деревьях Меркла, функции Диффи-Хеллмана, SHA-256 и другие методы.

Альтернативными алгоритмами консенсуса могут быть следующие:

- Proof-of-Stake (PoS). Вклад валидатора определяется долей внесенных денежных единиц криптовалюты от общего количества. Валидаторы подкрепляют добросовестность не затратами на вычисление, а активами внутри сети. Однако при использовании этого алгоритма возникает актуальная проблема отсутствия внесения активов (Nothing of Stake), т.е. валидаторами могут выступать участники без дополнительных затрат. Для ликвидации данной проблемы появились разновидности PoS, использующие принципы представительной демократии. Например, Delegated Proof-of-Stake (DPoS), Mutualized Proof-of-Stake (MPoS), Thresholded Proof-of-Stake (TPoS);

- Proof-of-Capacity, Proof-of-Weight, Proof-of-Spacetime. Данные алгоритмы консенсуса основаны на доказательстве выделения узлами нодов ресурсов для хранения цифровой информации;

- Proof-of-Authority (PoA). Основная идея заключается в предоставлении повышенных полномочий некоторым валидаторам. Используются в

управляемых и частично централизованных блокчейнах;

– Proof-of-History (PoH). В основу алгоритма положен процесс синхронизации работы всех узлов блокчейна и установления одинакового времени. Создается историческая запись, которая доказывает факт создания в определенный момент времени;

– Byzantine Fault Tolerance (BFT). Семейство алгоритмов консенсуса, направленное на защиту от сбоев сети блокчейна с помощью коллективного принятия решения и уменьшения влияния неправых узлов.

Сравнение основных алгоритмов консенсуса приведена в табл.2.

В последнее время расширение применения блокчейна в практической жизни приводит тому, что все больше проектов отходят от PoW и переходят к различным альтернативным алгоритмам консенсуса. Модификация алгоритмов идет по пути увеличения безопасности информационных данных, как например в PoS (доказательство доли владения). Для PoS характерно то, что вероятность генерации блока прямо пропорциональна балансу вложений валидатора. Для злоумышленника вкладывать средства для приобретения контроля будет невыгодно, так как курс возрастает прямо пропорционально спросу. Но если всё-таки ему это удастся, то атака становится нецелесообразной, так как он подвергает риску и свои вложения [16].

Таблица 2

Характеристики основных алгоритмов консенсуса

Алгоритмы консенсуса	Примеры проектов	Энергозатраты, кВт*ч в день	Количество полных узлов	Управление	Приоритетные характеристики
PoW	Bitcoin/ Ethereum (до 15.09.2022)	69974983/ 51765837	10102/ 12754	неформальное оффчейн-управление	децентрализованность, безопасность
PoS	Cardano	18630	12	ончейн-управление	масштабируемость
DPoS	Minter	30-45	16-256	ончейн-голосование	масштабируемость, низкое энергопотребление
BFT	Neo	51	7	ончейн-голосование +элементы оффчейн управления	масштабируемость, низкое энергопотребление
TPoS	Near	-	-	ончейн-голосование	масштабируемость

Примечание. Управление блокчейном обычно делится на 2 категории:

1. Ончейн управление – процессы принятия решений проходят через стейкинг и транзакции на блокчейне.

2. Оффчейн управление – процессы принятия решений проходят через неформальные процессы обсуждения и предложения вне блокчейна.

Кроме того, для масштабного внедрения блокчейна в цифровую экономику необходимо развитие не только рассмотренных технических аспектов, но и совершенствование нормативно-правовой базы, описывающей правила эксплуатации технологии и регулирующей отношения, возникающие при её использовании. А также немаловажной является и подготовка специалистов, разбирающихся в этих технологиях.

Заключение. Таким образом, как показано в статье технология блокчейн развивается как обособленная технология, которая применяется далеко за рамками систем криптовалют. Применение данной технологии в различных областях цифровой экономике и бизнесе за рубежом становится все более перспективным. Однако, экспертное сообщество обращает внимание на недостаточную изученность таких аспектов применения блокчейн как информационная безопасность, достоверность

данных, быстродействие, эффективность протокола взаимодействия узлов.

1. Проведенный анализ наиболее популярных и производительных блокчейн-технологий позволил выявить и обобщить их преимущества и недостатки с точки зрения технической реализации. Рассмотрены такие блокчейн-системы, как Bitcoin, Ethereum, Minter, Cardano, QTUM, Solana и другие.

Анализ функционирования вышеперечисленных блокчейнов и их характеристик подтвердил, что для повышения скорости обработки и финализации транзакций сетью блокчейн должен жертвовать либо децентрализацией, либо безопасностью. Таким образом, необходимо найти рациональное сочетание таких свойств технологии как децентрализация, безопасность и масштабируемость.

2. Для решения поставленной проблемы определены перспективные направления усовершенствования блокчейн-технологий, которые позволят обеспечить ее безопасное функционирование и снизить нагрузку на узлы системы. Одним из вариантов решения проблемы масштабирования является использование подходов, основанных на направленных ациклических графах.

Не меньшим потенциалом обладает и использование технологии шардинга, под которым будем

понимать горизонтальное разделение данных. Технология шардинга – перспективная и эффективная технология, позволяющая снизить сетевую нагрузку и нагрузку на процессоры нод блокчейна. На данный момент остаются нерешенными некоторые вопросы безопасности и эффективности шардинга, что не позволяет использовать данную технологию в промышленных масштабах. Но само направление развитие блокчейна является актуальным и перспективным на данный момент.

Важным аспектом развития технологии блокчейна является усовершенствование алгоритма консенсуса, который позволит оптимизировать работу и повысить защищенность сети блокчейн особенно с технологией шардинга. Показано, что одни алгоритмы позволяют строить надежные децентрализованные системы (Proof-of-Work), другие – блокчейны с большой пропускной способностью и масштабируемостью (модификации Proof-of-Stake). В статье проанализированы некоторые алгоритмы консенсуса и определены направления развития.

В дальнейших научных исследованиях за данной тематикой планируется построение модели осуществления консенсуса узлов с учетом шардинга, а также разработка оптимизированного алгоритма консенсуса, учитывающего аспекты безопасности, сетевой нагрузки и времени договоренности между узлами сети.

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