



# SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

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这些会议文结合了会议的材料 – 研究论文和科学工作者的论文报告。它考察了职业化人格的技术和社会学问题。一些文章涉及人格职业化研究问题的理论和方法论方法和原则。

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影响鞑靼斯坦共和国劳动、就业和社会保障部和鞑靼斯坦共和国国家信息技术和通信管理局数字发展部公务员有效工作的因素分析

**ANALYSIS OF FACTORS AFFECTING THE EFFECTIVE  
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DEVELOPMENT OF THE STATE ADMINISTRATION OF  
INFORMATION TECHNOLOGIES AND COMMUNICATIONS OF  
THE REPUBLIC OF TATARSTAN**

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抽象的。 本文分析了鞑靼斯坦共和国国家信息技术和通信管理局数字发展部和鞑靼斯坦共和国劳动、就业和社会保障部进行的调查结果。 影响劳动效率的因素已经被确定和研究。 制定了提高公务员劳动效率的建议。

关键词：效率、效率因素、公务员制度、公务员。

**Abstract.** *The article analyzes the results of a survey conducted in the Ministry of Digital Development of the State Administration of Information Technologies and Communications of the Republic of Tatarstan and the Ministry of Labor, Employment and Social Protection of the Republic of Tatarstan. Factors that influence labor efficiency have been identified and studied. Proposals have been formulated to improve the labor efficiency of civil servants.*

**Keywords:** *efficiency, efficiency factors, civil service, civil servant.*

The development of recommendations in the field of increasing the efficiency of civil servants is impossible without identifying factors that interfere with the implementation of the effective work of a civil servant, as well as identifying the main motivational factors that can increase the performance of a civil servant in executive bodies. We identified these factors using a specially conducted study - a survey.

The purpose of the study is to identify and analyze factors influencing the labor efficiency of civil servants.

As part of the study, the following tasks were solved: a questionnaire was developed and a survey was conducted in two ministries of the Republic of Tatarstan; factors that influence the increase in labor efficiency of civil servants have been identified; analyze respondents' proposals to improve operational efficiency; conclusions on the conducted research are formulated.

Based on the questionnaire of the Ministry of Labor of Russia from the "Methods of non-material and material motivation of state civil servants of the Russian Federation (approved by the Ministry of Labor of Russia) (together with Recommendations to the head of a structural unit of a state body on the formation of comfortable organizational, technical and psychophysiological conditions for professional activity)", adding and clarifying it questions for the study, we conducted a survey of civil servants in the Ministry of Digital Development of the State Administration of Information Technologies and Communications of the Republic of Tatarstan (Mindigitra RT) and the Ministry of Labor, Employment and Social Protection of the Republic of Tatarstan (MLE and SP RT). Using Google Forms, a questionnaire was sent to respondents by email. 60 people took part in the study. Of these, 30 are civil servants of the Ministry of Digital Development of the Republic of Tatarstan, 30 are employees of the Ministry of Labor and Social Protection of the Republic of Tajikistan.

Of the 60 respondents surveyed, the majority of women aged 25 to 45 took part in our study:

– in MLE and SP RT – 93% (28 people) are women and 7% (2 people) are men;

– in the Ministry of Digital Development of the Republic of Tatarstan – 83% (25 people) women and 17% (5 people) men.

In both authorities, the majority of respondents were between 25 and 45 years old:

– MLE and SP RT – 87% (26 people) – from 25 to 45 years old, 6.5% (2 people) – from 18 to 24 years old, 6.5% (2 people) – from 45 to 59 ;

– Ministry of Digital Development of the Republic of Tatarstan – 73% (22 people) – from 25 to 45 years old; 27% (8 people) – from 18 to 24 years old.

There are no respondents over 45 years old in the Ministry of Digital Development of the Republic of Tatarstan.

An analysis of the attractiveness of professional activities in government bodies showed:

– in MLE and SP RT, the majority of respondents (63% (19 people)) noted that serving in a government agency is prestigious; 20% (6 people) – stable work in the ministry; 17% (5 people) consider the managerial nature of the activity attractive;

– in the Ministry of Digital Development of the Republic of Tatarstan, 70% (21 people) of respondents say that service in a government agency is prestigious and 30% (9 people) believe that work in a government agency is stable.

Not a single respondent from the two ministries indicated attractive: the opportunity to gain professional experience and the opportunity for job growth. This suggests that civil servants do not consider opportunities for professional experience and job growth to be among the priorities in choosing this profession.

Answers to the question “What values determine the direction of your professional activities in a government agency?” gave the following results:

– in the Ministry of Labor and Social Protection of the Republic of Tajikistan, 60% (18 people) indicated stable income, 33% (10 people) social security, 7% (2 people) the opportunity to prove themselves as a professional;

– in the Ministry of Digital Development of the Republic of Tatarstan 63% (19 people) – stable income, 27% (8 people) – the opportunity to prove oneself as a professional, 10% (3 people) – social security.

So, the main value when choosing a profession for civil servants of both ministries is a stable income.

To the question “Do you think your professional potential (professional knowledge, skills, business qualities, etc.) is fully used in the workplace?”:

– in the Ministry of Labor and Social Protection of the Republic of Tajikistan, 83% (25 people) believe that their professional potential is fully used, 17% (5 people) believe that it is partially used;

– the majority of respondents from the Ministry of Digital Development of the Republic of Tatarstan (93% (28 people)) believe that their professional potential is used to the fullest, 7% (2 people) – their professional potential is partially used.

As we can see, none of the respondents indicated that their professional potential is practically not used, which means that civil servants make the most of their professional skills to perform their work.

From the survey we found that:

– in the Ministry of Labor and Social Protection of the Republic of Tajikistan, 63% (19 people) of respondents believe that the majority of civil servants work rather efficiently and only 37% (11 people) indicated that they are very effective;

– in the Ministry of Digital Development of the Republic of Tatarstan, 83% (25 people) of respondents indicated that they work effectively and 17% (5 people) - very effectively.

All respondents believe that the majority of civil servants work effectively. Not a single respondent believes that civil servants in their government agency are not working effectively.

When asked about factors preventing the full and effective implementation of official duties, civil servants indicated (several factors could be indicated) in the MLE and SP RT:

– 19 people – urgent assignments, constant change of activity, inability to concentrate;

- 17 people – overtime work, excessive workload;
- 15 people – poor technical equipment of the workplace;
- 14 people – conflicting instructions from management;
- 12 people – I am not satisfied with the salary level;
- 7 people – I am not rewarded in any way for good work;
- 5 people – there is a bad psychological atmosphere in the team;
- 5 people – I haven't been promoted for a long time;
- 2 people – management underestimates me.

In “other,” respondents indicated:

- “slow operation of electronic work programs”;
- “assigning additional work that is not in my job description”;
- “lack of a working atmosphere in the team.”

In the Ministry of Digital Development of the Republic of Tatarstan:

– (24 people) – conflicting instructions from management;

– (22 people) – overtime work, excessive workload;

– (18 people) – urgent assignments, constant change of activity, inability to concentrate;

- (16 people) – I haven't been promoted for a long time;
- (12 people) – I am not satisfied with the salary;
- (8 people) – doing work for others;
- (5 people) – management underestimates me;
- (2 people) – there is a bad psychological atmosphere in the team.

In “other”, respondents at the Ministry of Digital Development of the Republic of Tatarstan indicated:

- “a large number of “urgent” meetings”;
- “offsite conferences and meetings”;
- “lack of communication between departments (no desire to help)”;
- “short deadlines for completing the work.”

Factors chosen by the majority of respondents from two ministries:

– urgent orders, constant change of activity, inability to concentrate (MLE and SP RT – (19 people), Ministry of Digital Development of the RT – (24 people));

– overtime work, excessive workload (MLE and SP RT – (17 people), Ministry of Digital Development of the RT – (22 people));

– conflicting instructions from management (MLE and SP RT – (14 people), Ministry of Digital Development of the RT – (24 people)).

None of the respondents believe that the inability to undergo advanced training is not considered a factor that can affect labor efficiency.

The respondents indicated the following factors that could influence civil servants to work more efficiently (several factors could be specified).

In MLE and SP RT:

- 28 people fair distribution of workloads;
- 22 people remuneration in accordance with results;
- 17 people good technical equipment, work on high-quality equipment;
- 15 people opportunity for promotion;
- 11 people good relationships with work colleagues;
- 8 people stress-free work;
- 5 people recognition and approval from management;
- 5 people opportunity for training and advanced training.

In “other” respondents indicated:

- “a large working space is required”;
- “equal opportunities in communication with management.”

In the Ministry of Digital Development of the Republic of Tatarstan:

- 25 people fair distribution of workloads;
- 19 people remuneration in accordance with results;
- 13 people opportunity for promotion;
- 12 people good relationships with work colleagues;
- 10 people stress-free work;
- 8 people flexible work schedule;
- 5 people good relationship with the boss;
- 5 people recognition and approval from management;
- 2 people opportunity for training and advanced training.

In “other” respondents indicated:

- “specific instructions from the manager are needed”;
- “it is necessary to improve the lighting in the room”;
- “non-material motivation”.

So, respondents from both ministries identified the following main factors that can increase labor efficiency:

- fair distribution of work volumes (MLE and SP RT – (28 people), Ministry of Digital Development of the RT – (25 people));
- remuneration in accordance with the results (MLE and SP RT – (22 people), Ministry of Digital Development of the RT – (19 people));
- good relationships with work colleagues (MLE and SP RT – (11 people), Ministry of Digital Development of the RT – (12 people));
- opportunity for career advancement (MLE and SP RT – (15 people), Ministry of Digital Development of the RT – (13 people)).

Not a single respondent from the two ministries indicated the following factors: salary increases; ability to perform complex and responsible work; good relationships with colleagues.

It should be noted that respondents chose some factors that could increase the efficiency of work in one ministry more often than in another. For example, in

MLE and SP RT “good technical equipment, work on high-quality equipment” was chosen by the majority of respondents (17 people), but no one chose the same factor in the Ministry of Digital Development of the RT. This fact suggests that when determining factors that can make work more effective, it is necessary to know the specifics and capabilities of a particular ministry.

We found out how much remuneration for work results depends on its effectiveness. In MLE and SP RT, the majority of respondents (80% (24 people)) indicated that remuneration largely depends on the effectiveness of their work, only 20% (6 people) noted - partially. In the Ministry of Digital Development of the Republic of Tatarstan, the answers of respondents to this question were distributed - 87% (26 people) - remuneration largely depends on the effectiveness of their work and 13% (4 people) indicated that it partially depends. None of the respondents indicated that remuneration does not depend on performance at all.

Remuneration greatly influences performance. It is desirable that the salary of the employee corresponds to the position, size of the workload and level of responsibility. And the respondents' answers did not confirm this. The majority of respondents in the Ministry of Labor and Social Protection of the Republic of Tatarstan (80% (24 people)) indicated that it partially complies and only (20% (6 people)) - yes, it complies. The Ministry of Digital Development of the Republic of Tatarstan has a similar distribution of votes: 93% (28 people) - partially complies and 7% (2 people) - yes, complies. When asked about satisfaction with monetary remuneration for work, the majority of respondents (77% (23 people)) in the Ministry of Labor and Social Work of the Republic of Tatarstan indicated that they were partially satisfied, and 23% (7 people) were completely satisfied with the monetary remuneration. In the Ministry of Digital Development of the Republic of Tatarstan, the votes of respondents were distributed as follows: 90% (27 people) are completely satisfied with the salary and only 10% (3 people) are partially satisfied.

To the question “what can be done to improve the efficiency of a civil servant?” were the following answers:

in MLE and SP RT:

- “the manager should correctly distribute responsibilities among employees;
- “don’t leave work for later”;
- “use the full potential of each employee”;
- “timely send employees for advanced training”;
- “to improve technology in departments”;
- “managers and employees to establish good and friendly relations between departments”;

in the Ministry of Digital Development of the Republic of Tatarstan:

- “conduct team building for employees”;

- “develop training programs for new employees”;
- “reduce or optimize reporting collection”;
- “gather employees’ opinions about problems related to their work.”

Based on the research conducted for two ministries, the following conclusions were formulated:

- factors that can influence civil servants to work more efficiently: fair distribution of workloads, remuneration in accordance with results, good relationships with colleagues at work, the possibility of promotion;
- salary and remuneration should depend on the performance of the civil servant;
- in order to increase the efficiency of a civil servant, it is necessary to establish good and friendly relationships in the team, conduct team building, develop training programs for new employees, and productively use the potential of each employee.

税收安全评估 (以马加丹地区为例)

## TAX SECURITY ASSESSMENT (USING THE EXAMPLE OF THE MAGADAN REGION)

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注解。 本研究的目的是以马加丹地区为例,分析确保地区税收安全的实践。作者探讨了税收安全的本质和特征、其现实意义以及个人安全工具。对现有实施该流程的机制的优点和缺点得出了结论。

关键词: 税收法律关系、区域方面、税收安全。

**Annotation.** *The purpose of the study is to analyze the practice of ensuring regional tax security using the example of the Magadan region. The author examines the essence and characteristics of tax security, its practical significance, as well as individual security tools. Conclusions are drawn about the advantages and disadvantages of the existing mechanism for implementing the process.*

**Keywords:** *tax legal relations, regional aspect, tax security.*

**Introduction.** Taxes and tax policy in general are an important component of ensuring the economic security of the state and its individual regions. With the transition to a market economy and management mechanisms, the importance of this element only intensified, acquiring almost decisive significance in the overall volume. Tax policy, like nothing else, is uniquely and most closely related to the real sector of production and reproduction, business activity, i.e., through tax instruments it is possible to influence the existing level of national security equally positively and negatively.

Ultimately, all this convincingly indicates in favor of carrying out additional scientific developments and research on the designated topic.



This article discusses the features of the practical implementation of the mechanism for ensuring tax security in the Magadan region.

Methodology combines elements of descriptive analysis with secondary processing of statistical data.

**Main part.** Tax security is rightfully identified by most authors with the stability of the entire taxation system as a whole. Ultimately, this term can be used to define such a state of the taxation system of a state, region, municipality, or even a specific organization, which fully ensures guaranteed replenishment of the budget of the appropriate level, in order to increase the level of socio-economic development. As criteria for the stability of tax security in general, the two most important ones are identified: stability, certainty and the maximum level of tax revenues to the corresponding budget [2; 3].

Also among the factors influencing the status of tax security, it is necessary to highlight the following:

- economic opportunities of taxpayers;
- degree of impact of the tax burden;
- prospects for the development of economic entities;
- deviance of economic behavior of taxpayers;
- problems of criminalization of society, etc.

In other words, tax security is a complex, systemic instrument of real influence on socio-economic processes, part of economic security as a whole.

We also note that at present there is no single concept dedicated to tax security, there are no clear methodological and legal foundations, and therefore the issues of implementing tax security are relevant for discussion among political scientists, economists, lawyers and a number of other scientists [6; 9].

To consider the economic status of the Magadan region, we will analyze the data from the Monitoring of the main economic and demographic indicators of the region, which is traditionally carried out by Rosstat on the basis of the basic version of forecasts for the socio-economic development of the constituent entities of the Far Eastern Federal District (as of January 2023).

So, the region's GDP indicators are traditionally positive, with the main growth coming from the mining and electricity sectors. In the period 2023-2025, further growth is also forecasted at no less than average levels based on the traditionally high data on economic development. Mining also gives positive dynamics in relation to industrial production, where, for example, over the past year the production index exceeded 100%. The level of investment in fixed assets showed an increase of 5.6% compared to the previous year; further growth is predicted due to the development of several large construction and recreational regional projects at once [10].

Indicators of agricultural production and retail trade are also growing, although in the latter case the increase is minimal - slightly more than 1% for 2022. The situation on the regional labor market remains stable, the level of overall unemployment has decreased, which is predicted to continue in the future. At the same time, the growth in real incomes of the population of the Magadan region compared to 2021 was 97%, and the share of the population with cash incomes below the subsistence level is estimated by experts at 7.9%. Among the analyzed demographic indicators, we note that the natural population decline continues, the migration outflow is growing, and the life expectancy of residents remains below the national average. Other indicators of the region's SER are presented in Table 1.

**Table 1**  
*Indicators of socio-economic development*

Magadan region (optional) [2]

<b>Indicator name</b>	<b>2019</b>	<b>2020</b>	<b>Growth rate, %</b>
Volume of GRP per capita, thousand rubles.	1,524.00	2,035.20	193
Degree of OS wear, %	36.6	40.0	98.3
Consolidated budget deficit/surplus, as a percentage of GRP	- 0.46	+ 0.24	19 times
Consumer price index, %	102.6	105.0	101.3
Share of unprofitable organizations, as a percentage of the total number of organizations in the region	36.2	35.8	103.7

Other tables present the situation with tax revenues in the region in more detail (see tables 2 and 3).

**Table 2**  
*Main budget-forming tax indicators of the budget of the Magadan region (for 2022)*

<b>Name of tax/indicator/criterion</b>	<b>Share in total tax revenues, %</b>
Personal income tax	42
Corporate income tax	28
MET	13
Organizational property tax	9
Other taxes	8

**Table 3**  
*Growth in tax revenues to the budget of the Magadan region (for 2022, compared to 2021)*

Name of tax / indicator / criterion	Share of the growth, %
Special tax regimes	40
Receipts to extra-budgetary funds	5
Tax payments (using the example of the unified agricultural tax)	31

The indicators presented above confirm statistically that the most developed in the region, including from the point of view of taxation, are the mining industry and business activities aimed at meeting the needs of the population. Among the special tax regimes, the system of simplified taxation received the greatest expression, the growth of which amounted to about 405 million rubles, which indicates that small businesses and individual entrepreneurs are quite active in the region, which from a practical point of view also solve many important social functions.

Therefore, we can say that it is the types of tax revenues presented in the tables that most ensure the stability and sustainability of the tax security of the Magadan region at the present stage. In addition, they make up a significant percentage of the overall economic security of the region as a whole and allow for high-quality forecasting and planning.

In other words, we can say that, despite the rather serious remoteness from the central part of Russia, nevertheless, the Magadan region maintains fairly high indicators of socio-economic development according to a variety of criteria, sagging only in demographic data - which is also quite logical and understandable. Climatic conditions, favorable geographical location and resource capital allow the region to remain quite stable and sustainable both at the level of the Far Eastern Federal District and among other subjects of the federation as a whole [5; 8].

Next, we will turn in more detail to the tax policy of the region.

Strengthening the tax potential of the region, increasing the volume of tax and non-tax revenues, achieving the planned profitability indicators of the consolidated budget of the Magadan region continue to be among the most relevant and promising areas for the development of the regional economy.

Thus, during the period of 2016-2018, a complex analytical work was carried out where the tax burden, exemptions, and regimes in place in the region were thoroughly examined. As a result of the systematic work carried out, a number of regional benefits were optimized, which did not meet the current tasks of the socio-economic development of the Magadan region; similar actions were taken in relation to local taxes, which turned out to be actually unprofitable for the budget. The tax rates of some types of taxes were also subsequently revised - for example, transport tax for individuals and legal entities [1].

Additionally, the establishment of maximum tax rates for the gambling business tax, which was introduced in 2018 and caused a significant increase in the volume of cash injections into the income of the regional budget of the region, contributed to increasing the stability of the region's tax security.

At the same time, as experts rightly note, the state of tax security in the region largely depends on federal tax policy. As an example, we can cite the changes that came into force in 2019, which qualitatively influenced the formation of the consolidated budget of the region.

The Magadan region is traditionally a subsidized region, and this is a rather vulnerable characteristic of the region, which experts point out as one of the relevant areas for the development of the region's economy. This also contributed to the improvement of work regarding tax incentives and rates, and became the basis for the development of a plan of the Government of the Magadan Region to eliminate ineffective tax incentives, which has been implemented since 2019.

All of the above together makes it possible to relatively successfully achieve a balanced regional budget and significantly strengthen tax potential and budget discipline.

In the future, as experts note, the tax policy of the region will also be aimed at the formation and development of an effective tax system, which, with all its tools, together contributes to ensuring budgetary sustainability, both in the short and long term [4].

**Conclusion.** To summarize the issue considered in the work, we briefly outline the following conclusions.

Tax security is an important component of economic security and directly the national security of the region and the country as a whole. Its formation is influenced by a whole set of various factors of both a socio-economic, demographic and political nature.

The SER of the Magadan Region, as the analysis presented in this work shows, has a number of significant shortcomings, but on the whole it can be assessed rather positively. The same applies to tax security, especially based on the results of events carried out by the regional authorities over the past 3-5 years.

This is evidenced by a number of tangible tax policy measures taken in relation to tax benefits, rates, factors reducing budget subsidies and ensuring a surplus of the consolidated budget. It is emphasized that the system of analytical and assessment activities carried out by the regional leadership has created the necessary basis for further positive changes, which experts predict for the period at least until 2025, and possibly beyond.

All this allows us to speak not only about the relative stability and stability of the region's tax security, but also about its promising future.

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线上和线下平台上的神经营销工具  
**NEUROMARKETING TOOLS ON ONLINE AND OFFLINE  
PLATFORMS**

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抽象的。 本文讨论了现代经济形势下消费者行为的特征，线上和线下市场主体必须考虑这些特征，以形成客户群并增强竞争地位。 神经营销学作为组织市场活动的战略和战术工具的多维性已经确定。 提出了对目标消费者群体的探索性研究结果，揭示了他们对某些神经营销触发因素的态度。

关键词：网上购物、消费者行为、神经营销触发因素、购买活动。

**Abstract.** *The article discusses the features of consumer behavior in the modern economic situation, which must be taken into account by subjects of online and offline markets to form a client base and strengthen their competitive position. The multidimensionality of neuromarketing as a strategic and tactical tool for the organization's market activities has been determined. The results of an exploratory study of the target group of consumers are presented, their attitudes towards some neuromarketing triggers are revealed.*

**Keywords:** *online shopping, consumer behavior, neuromarketing triggers, purchasing activity.*

The classic goal of successful market activities of organizations associated with the marketing concept of management is “to find a need and satisfy it.” Consumers vote “with rubles” for the company and its products, determine its market positions (leader, contender for leadership, etc.). Factors of the macro and micro external environment are changing, strategies and tactics of consumer behavior are changing. Knowledge of consumer trends and characteristics of consumer be-

havior provides organizations with the opportunity to maneuver in different economic situations and reduces the degree of risk [1,2,3,4].

In 2023, the following trends in consumer behavior are identified [5]. The first trend is associated with consumer orientation towards thrift and the strategy of “smart consumption”. This is a stable, traditional consumer behavior that was formed more than 10 years ago. The second purchasing strategy involves “sales.” Key concepts of this trend: “value of money”, “value of time”, “value of assortment”. The third trend is determined by the growth trends in online commerce, the remote shopping sector and the number of online buyers. However, according to the researchers, this did not affect the purchase decision process. The fourth trend is associated with the “young parents” segment, whose consumer strategy can be called “conscious environmental consumption.” The fifth trend is determined by the introduction of new goods and brands to the market as a result of import substitution.

Topface Media, a digital agency, conducted a study of consumer behavior in 2023 and identified the following trends that shape consumer insights: conscious consumption, shopping on sales, a request to slow down, environmental agenda, interest in local, a reasonable approach to shopping, the place of money in the model happiness, technological fatigue, attention to health. They are based on the following characteristic features of consumer behavior: meeting current needs and redistributing the budget in their favor, reconsidering priorities when planning purchases, the growing popularity of marketplaces, thrift and restraint when purchasing, an environmental approach to choice, etc.[6]. Knowledge, understanding and practical application of these strategies in market activities will allow the company to improve the customer focus of its business.

In modern market conditions, companies have an increasing need and interest in new approaches, methods of work, and interaction with target consumer groups. One such method is neuromarketing. The website of the scientific electronic library eLIBRARY.RU, the largest Russian information and analytical portal, published 1148 articles on neuromarketing [7]. Based on the results of the analysis of the titles of one third of the publications, it is possible to determine the areas of application of neuromarketing. These include: hotel business, markets for financial, tourism, medical and other services, stock markets, entrepreneurial and advertising activities of organizations, pharmacy organizations, banking sector, universities, pharmaceuticals, textile and retail trade, education, injection medicine, sports nutrition, furniture stores, music industry, fruit juice production, media, automotive retail, children’s goods markets.

The subject of the research, which is associated with the scientific interest and practical significance of neuromarketing, is consumer behavior, legal aspects of the organization’s market activities, a model of strategic management of neuro-

marketing, sales promotion, consumer loyalty, ethics and ethical aspects, financial risk management, demand management, promotion in social networks, branding, formation of neurobranding, etc.

Neuromarketing is considered from the following perspectives: trends in marketing; modern type of marketing; behavioral neuromarketing; a tool for managing demand and increasing competitiveness; marketing research method; innovative method of consumer research; way, method, promotion tool; method of forming visual salience; a tool for manipulating people; a way to attract and retain consumers; creating effective content; a means of stimulation and a tool for increasing consumer loyalty; innovative mechanism for manipulating consumers; a tool for persuading consumers, etc.

One of the ideas of neuromarketing is related to the fact that all information reaches consumers through perception channels. The main channels of influence on consumers, neuromarketing triggers, are vision, hearing, smell, touch, taste, and attractiveness (a set of positive memories). Neuromarketing must be able to cover all these channels to achieve its goal. Triggers are a “psychological message”, a “trigger mechanism” that influences emotions on a subconscious level and encourages the client to buy. The main neuromarketing triggers that are used to increase sales: color, sound, taste, smell, touch, light [8].

Two marketing studies were conducted aimed at identifying consumer attitudes towards neuromarketing triggers as one of the elements of an organization’s marketing communications with actual and potential online and offline customers. The object of the study were students of two Kazan universities, economic and technical areas of training. The sampling unit is representatives of the target segment “students”, generation Z, born from 1995 to 2012. Their consumer behavior was formed during the period of digitalization of society, the digital economy, the development of the online sales market, and the development of neuromarketing tools in the market activities of organizations. The narrow target sample size was 100 respondents. Data from two focus groups were used to develop questionnaires for the online survey.

The first study was aimed at obtaining information about consumer perception of neuromarketing triggers, which are elements of merchandising of offline stores. A fairly high degree of activity in the offline sales market was revealed (68%). The most important factors in choosing a store are the quality of the product and its price. Only a third of respondents rate “atmosphere” highly as a selection criterion.

More than half of buyers (58%) rarely make unplanned purchases. Almost a third of respondents chose the answer options about frequent unplanned purchases. The degree of influence on spontaneous (unplanned) purchases of respondents by the following factors was revealed: pleasant atmosphere of the sales floor, convenient location of goods, product design, advice from a consultant. Based on the



number of respondents who gave high marks (4 and 5), it is possible to create a unique rating of factors influencing this type of purchase: product design (64%), convenient location of goods (24%), pleasant atmosphere of the sales area (18%), advice from a consultant (6%). Two-thirds of respondents pay attention to music on the sales floor. For only 4% of buyers it does not matter. A third of respondents found it difficult to answer the question about which product shelf they most often take goods from. Half of the respondents prefer the middle product shelf.

The second online survey provided information on attitudes towards online shopping. More than 80% of respondents often make purchases in online stores. Criteria were identified that determine the choice of online store/marketplace for purchases: personal offer (2.9 points), free delivery (4.46 points), design and convenience of the platform (4.12 points), availability of reviews (4.36 points), the presence of a photo of the product that reveals its functionality (4.32 points). The attitude of respondents towards unplanned, spontaneous purchases was revealed.

Every fourth student surveyed very rarely makes such purchases. However, often 40% of respondents – often. Marketing tools that influence this type of purchases in online stores/marketplaces were analyzed. “Discounts” have the greatest influence on respondents (average score 4.12). 80% of respondents gave the highest scores in terms of influence. Good reviews influence 60% of respondents (average score 3.7). According to respondents, the least influence on unplanned online purchases is exerted by “description of the product” and “photos of the product in various life scenes.” The design colors of online shopping platforms are of great importance to 60% of respondents. A third of respondents do not pay attention to this.

Thus, having identified the attitude of buyers to neuromarketing tools, it is possible to formulate the tasks of neuromarketing research on tools to influence purchasing behavior and the purchase decision-making process.

Today there is an ambiguous attitude towards neuromarketing [9]. On the one hand, it allows you to deeply understand consumers at the level of their subconscious, instincts and increase consumer loyalty, the effectiveness of the communication system, and the level of sales. On the other hand, it is necessary to take into account the ethical aspects of sales, not to violate the principles of confidentiality of information, not to allow manipulation of the minds of target consumers and not to violate the secrets of their personal lives.

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计划经济与税收的理论框架：对中产阶级的影响分析与税收方案的优化  
**THEORETICAL FRAMEWORK OF THE PLANNED ECONOMY  
AND TAXATION: ANALYSIS OF THE EFFECT ON THE MIDDLE  
CLASS AND OPTIMIZATION OF TAX SCHEMES**

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抽象的。所提出的研究综述对税收定理进行了批判性分析，由 E.S. 撰写和证明。2021年的马纳希洛夫提出了自1789年以来“税收问题”的解决方案，也是博弈论框架内的第一个重大定理，以及其在市场经济和计划经济背景下的应用和对结构性的影响。中产阶级的组成部分。基于税收制度和国家经济模式是决定中产阶级特征和能力的重要因素，似乎有必要对税收定理进行推广和进一步优化。该研究框架内证明的主要创新在于，累进税制下的良性竞争是不可行的，而中产阶级作为经济和社会政治结构的组成部分是国家稳定的决定因素。在计划经济的框架内，由于某些经济和社会原因，中产阶级的存在根本不可能存在，本书对此进行了详细分析。

该研究还包括对用作税收定理基础的税收优化方法的批判性分析。提出了一种系统方法来确定直接税和间接税的最佳比例，以及随后将其纳入国家经济政策。这项工作理解复杂经济系统及其与税收政策关系的重要一步。

关键词：税收定理、计划经济、中产阶级、税收、经济稳定、社会政治结构、税收制度优化。

*Abstract. The presented research review provides a critical analysis of the Tax Theorem, written and proven by E.S. Manashirov in 2021, which is a solution to the “tax issue” that has been standing since 1789 and the first major theorem within the framework of game theory, as well as its application in the context of market and planned economy and impact on the structural components of the middle class. Based on the fact that the tax system and the economic model of the state are integral factors determining the characteristics and capabilities of the middle class, it seems necessary to generalize and further optimize the Tax Theorem. The main innovations proven within the framework of the study are that healthy competition with a progressive tax scale is unviable, and the middle class as an integral part of the economic and socio-political structure is a determinant of the stability of the state. Within the framework of a planned economy, the existence of a middle class becomes fundamentally impossible for certain economic and social reasons, which are analyzed in detail in this work.*

*The study also includes a critical analysis of the tax optimization methodology used as a basis in the Tax Theorem. A systematic approach is proposed to determine the optimal proportions of direct and indirect taxes, as well as their subsequent integration into the economic policy of the state. This work is a significant step in understanding complex economic systems and their relationships with tax policy.*

**Keywords:** *Tax Theorem, planned economy, middle class, taxation, economic stability, socio-political structure, optimization of the tax system.*

### **Introduction**

Modern economic realities emphasize the relevance of a deep analysis and understanding of taxation mechanisms and their impact on the socio-economic structure, in particular on the middle class as one of the key components of the sustainable development of the state. Interest in this topic is due not only to the academic significance of the issue, but also to the practical need to optimize the tax system. The purpose of this article is to provide a comprehensive analysis of the Tax Theorem and its application in the context of a planned economy, with an emphasis on the relationship with the state of the middle class.

The work is structurally divided into several key sections. The first section is devoted to the analysis of the concept of the middle class in economic science, its role in ensuring economic stability and socio-political sustainability. The second section focuses on the Tax Theorem and its role in optimizing the tax system, as well as its possible impact on the middle class. The historiographical aspect is discussed in the third section, which analyzes the significance of the Tax Theorem in the context of academic discourse and its place among other significant theorems in the field of economics [1].

The author strives not only to highlight the issue of taxation and its impact on the middle class, but also to offer a set of tools for further research and practical implementation. An important aspect of the work is the integration of various scientific approaches and methodologies for a comprehensive analysis of the subject of research.

Since 1789, since the time of the Great French Revolution, the question has been particularly acute as to why most of big capital, which is the basis of the market, supports the left, lobbying for anti-market laws, the apogee of which is the “progressive scale of taxation”. Embodying the tilt of the economy to the left, in contrast to the flat tax scale, it assumes an increase in the tax rate as a percentage of income, that is, for example, on an income of 100 gold, the tax is 15%, and on 1000 gold - 30%. And at this stage, it seems that the progressive scale is beneficial to everyone, because the rich will still not go bankrupt, and it will become easier for the poor. But one of the key questions for considering this work is why does the rich need it in this case [3-6]?

The answer is that the progressive scale destroys competition by disincentivizing entrepreneurs from medium-sized businesses to invest in order to move to a large one, since the enterprise either risks falling back or going bankrupt, since they will suddenly begin to take many times more money from it. But if it is still at least somehow possible to become rich from average, then the transition from a rich stratum to a super-rich one is observed only in isolated cases per decade.

Thus, the super-rich sacrifices one eye to make the rich blind, receiving “gross profitability”, because the conditional Bill Gates does not care whether he has a billion or a hundred billion, the main thing is that no one else has even a million.

And moreover, even for the poor, the progressive scale is beneficial only as long as he decides to remain poor, because if he wants to develop, he opens a conventional shawarma shop and makes the transition to a higher class. Its main obstacle will be precisely the progressive tax, which, among other things, is the personification of the phrase “neither for ourselves nor for the people,” since within any economic system to which it is applied, creativity is killed and the expansion of the space of effective strategies is stopped through artificial stagnation of the market, and the possibility of the emergence of an “absolute advantage” between enterprises that are close to equality in terms of capitalization and level of development is also destroyed [8].

Thus, the progressive scale not only oppresses the free market, but is a union of those who are at the top and do not want to change anything, and those who are so low that they do not believe in the very possibility of change. It is a “coalition of the super-rich and super-poor against the middle class” (and everyone else).

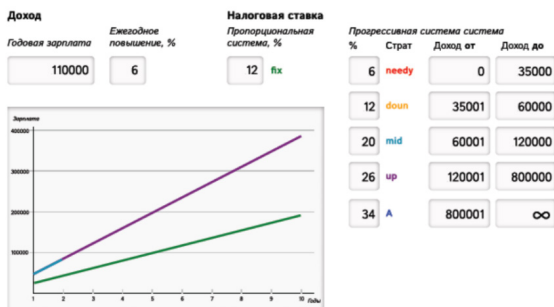
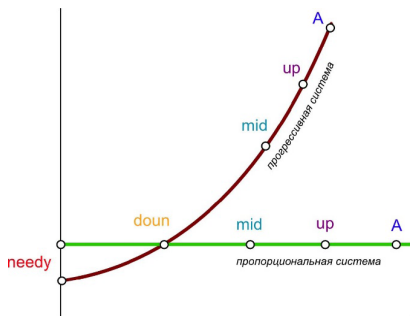
Note 1: this theorem does not apply or is applied with errors if it is used in the situation of an absolutely degenerate market or the situation of a “pseudo-progressive scale”, i.e. when the rate increase is insignificant (up to 4–5%~), as for example in the Russian Federation from 2021, and is applied in a super-optimal manner in the case of a “super-flat tax scale”, i.e. when benefits and financial withdrawals from the state, not included in taxes, directly become part of them.

Note 2: This theorem is a solution to the “tax question”, whose date is reported from the Great French Revolution (1789), since it was after it that the prospect of introducing progressive taxation at the state level first began to be considered seriously. And it was introduced in Great Britain by Prime Minister William Pitt the Younger in December 1798.

Note 3: The last serious attempt to solve the «tax question» was made by John Keynes and Frank Ramsay, which resulted in the latter’s 1927 article «A Contribution to the Theory of Taxation».

$$\begin{cases} \sum_s(A + \Omega^{needy}) \gg \sum_s(B^{up} + B^{mid} + B^{down}) \\ \sum_n(A + \Omega^{needy}) \ll \sum_m(B^{up} + B^{mid} + B^{down}) \end{cases}$$

$$\left\{ \begin{array}{l} P_{\S}(A + B^{up} + B^{mid} + B^{down} + \Omega^{needy} | S^{\rightarrow}) > P_{\S}(\dots | S^{\nearrow}) (1) \\ \sum_n (A + \Omega^{needy}) \ll \sum_m (B^{up} + B^{mid} + B^{down}) (2) \\ R_{\S}(S^{\rightarrow}) > R_{\S}(S^{\nearrow}) (3) \\ P_{\S}(A + \Omega^{needy} | S^{\nearrow}) > P_{\S}(A + \Omega^{needy} | S^{\rightarrow}) (4) \\ \int_T P_{\S}(A + \Omega^{needy} | S^{\rightarrow}) dt - \int_T P_{\S}(\dots | S^{\nearrow}) dt < \\ < \int_T P_{\S}(B | S^{\rightarrow}) dt - \int_T P_{\S}(B | S^{\nearrow}) dt (5) \end{array} \right.$$



Введенные обозначения:

$R_{\S}$  – market condition

$P$  – player’s winnings (profit)

$P_{\S}(X|S)$  – player profit  $X$  at  $S$  strategy:

$S^{\rightarrow}$  flat tax scale

$S^{\nearrow}$  progressive scale

Players:

$A$  – stratum player of the super rich group of players B (beta)

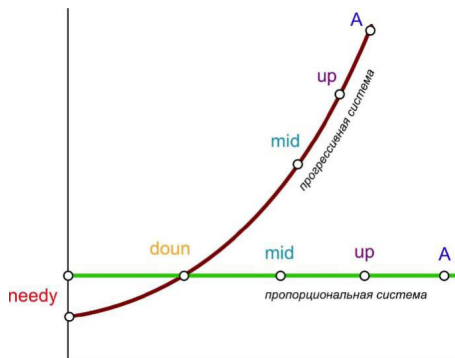
$B^{up}$  – stratum player of the rich

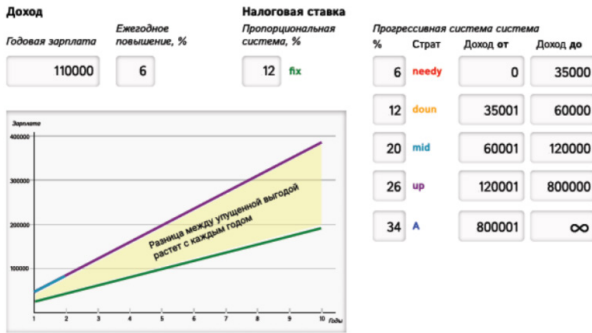
$B^{mid}$  – middle class stratum player

$B^{down}$  – player-stratum of the poor  
 $\Omega^{needy}$  – player-stratum of the ultra-poor  
 $T$  – long-term strategy horizon (investing),  
 $T \gg 1$  year

1. *The first inequality* proves that the financial benefit for the social strata of all economic units (both firms and households), all players - market agents in total equivalent, regardless of the stratum, is maximum with a flat tax scale in accordance with the Pareto optimum, since the general welfare of society as a whole reaches a maximum, the distribution of goods and resources becomes optimal in accordance with the main theorem of mathematical game theory: “The price of the game does not decrease from the expansion of the strategy space,” i.e. The more money a person has left after paying taxes, the more varied he can spend it. Any increase in taxes as a result of a progressive scale cannot be Pareto optimal relative to the mathematical theory of games and the realities of the market.

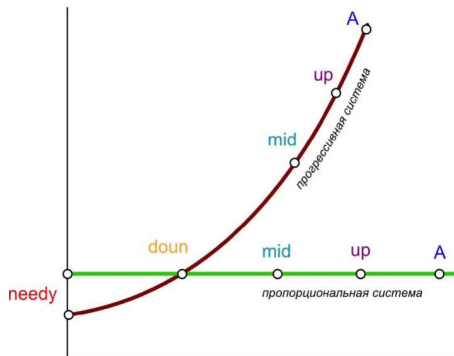
*Note.* In turn, as with progressive, due to the artificial complication of class rotation, commensurate benefits are possible only for the smallest economic units, since they are not able to influence the position of the market independently (i.e., the super-poor) and serve as a lever for devaluing the middle class through artificial degeneration of the economy on the part of the super-rich.



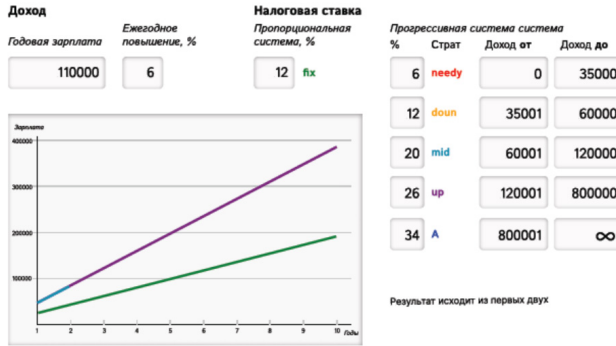


2. *The second inequality* proves that the state of the market with a flat scale is preferable, since, in accordance with the above integrals, it means the following: the difference between the two integrals, indicating the lost profit of the super-rich and the super-poor, indicates that with a flat scale, not only the total gain, but and the difference between lost profits, i.e. how much could the strata gain to increase their capitalization? With a flat scale relative to the progressive scale, the lost profit is less, since the opportunity to multiply capital is lost, and therefore the super-rich and super-poor, being much smaller (in terms of the number of economic agents composing the stratum) than everyone else, form an alliance in order to impede the expansion of the space of effective strategies, killing of creativity and artificial degeneration of the market.

*Note.* This explanation is correct, in addition to the evidence given earlier, also because it is the only possible one with respect to the criteria of classical Bayes and any possible approach to probability theory and mathematical modeling of economic issues in general.







3. *The third inequality* proves that the benefit of the strategy of the union of the super-rich and the super-poor is possible if and only if it occurs at the expense of the benefit of the entire society as a whole. In accordance with this, for society, a market with a flat scale is preferable (more perfect) to a market with a progressive scale.

*Note.* The key characteristic feature of the emergence of the middle class as something stable and having a significant economic impact is the condition of the Tax Theorem, since the progressive scale, being an economic response to the financial and political growth of the middle class, which, coupled with its stabilization, causes a natural optimization of the market, giving awareness which  $B^{mid} >> 0$ , is the last means of stopping it on the part of A.

4. *The fourth inequality* proves that only for stratum A (the super-rich) is it strategically fully beneficial  $S^{\nearrow}$  (a progressive tax scale); in turn, the stratum  $\Omega^{needy}$  (the super-poor), as emphasized earlier, is not able to influence the position of the market independently and serves as a lever for devaluation  $B^{mid}$  (average class) through the artificial degeneration of the economy on the part of the super-rich.

*Note.* It makes sense to add that such a disastrous situation would hardly have been possible if the Tax Theorem had been known at the time of its inception  $S^{\nearrow}$  (of the progressive scale) or at least in the 20th century.

5. Why does the fourth inequality hold: although every quarter with a  $S^{\nearrow}$  (progressive scale) A pays more taxes than with  $S^{\leftarrow}$  (a flat scale), at the same time A, as repeatedly stated above, suppresses its potential economic competitors  $B^{up} + B^{mid} + B^{down}$ , using as an instrument  $\Omega^{needy}$ , without giving or minimizing the opportunities  $B^{up} + B^{mid} + B^{down}$  for high-quality rotation, the use of a creative approach and the transition to the stratum of the super-rich. It should be assumed that there are three reasons for this strategy. Firstly, this is a simple consideration of the limited resources in the economy as such, i.e. the more A (super-rich), the less wealth they have. Secondly, the expansion of the number of representatives of

stratum A erodes the value of wealth within this stratum - a decrease in the elitism of wealth. And thirdly, an ordinary compilation of generally accepted fear and conventional laziness, i.e. on the one hand, this is the fear of becoming morally obsolete and being surpassed, and on the other hand, the strategy  $S^{\nearrow}$  (progressive tax) allows you not to develop, without being afraid of being surpassed.

*Note:* the fourth inequality is the leading statement of the theorem, and the fifth clearly reveals its reason, from which it follows that, in accordance with the Law of Contraposition, all other inequalities are true. And the final fact that Manashirov's Theorem on Taxes proved is: "A flat tax scale is Pareto optimal and more effective than any differentiated one. And since any non-flat scale is differentiated, a flat tax scale is the most effective tax scale possible within the framework of economic science."

*Note.* A flat tax scale is also more natural historically and has undergone natural selection.

Six quantities that are calculated in the theorem:

$$P - B^{up} + B^{mid} + B^{down} \text{ at } S^{\rightarrow}$$

$$P - B^{up} + B^{mid} + B^{down} \text{ at } S^{\nearrow}$$

$$P - A + \Omega^{needy} \text{ at } S^{\rightarrow}$$

$$P - A + \Omega^{needy} \text{ at } S^{\nearrow}$$

$$P - R_{\S} \text{ at } S^{\rightarrow}$$

$$P - R_{\S} \text{ at } S^{\nearrow}$$

### ADDITIONAL INFORMATION

#### Tax Theorem and Excessive Types of Taxation

In total, there are two generally accepted taxation scales in addition to flat and progressive - regressive, which at first glance is the direct opposite of progressive, and the so-called Negative Income Tax.

But in the Tax Theorem only flat progressive is considered, since it proved that any differentiated tax scale is not Pareto optimal and is fundamentally less efficient than a flat one. In other words, in fact, a flat tax scale is not only the most effective of the existing ones, but also the most effective of all possible ones relative to the current and all existing economic science. Moreover, the Negative Income Tax has been found to be financially unprofitable based on empirical research (the impact of tax loss offsets on investment decisions, the negative income tax and the evolution of the United States, Social Security Policy - American Economic Association).

The regressive scale, being a system in which the average tax rate decreases as the taxable amount increases, assuming that as the income of an economic agent increases, the rate falls, and, conversely, increases if income decreases, is not the opposite, but a logical development of the progressive scale. Because it also de-

stroys competition and the middle class, but not at the expense of the super-poor, but through the unification of the stratum  $A$  and  $B^{up}$  into one stratum against  $B^{mid}$ .

*The Tax Theorem* as a refutation of the Ramsey rule, Ramsey pricing, a solution to the Ramsey problem and as a stimulator for the application of the Keynes–Ramsey rule

*Ramsey problem*: what prices should a government monopoly charge for the various products it sells in order to maximize social welfare (the sum of producer and consumer surplus) while generating enough revenue to cover its fixed costs. (The Ramsey problem is generally considered the second most important problem in modern economics.)

*Ramsey Pricing* (Ramsey Pricing is a solution to the Ramsey problem from Ramsey's point of view): to minimize deadweight losses, prices need to be raised to rigid and elastic requirements in the same proportion to the prices that will be charged. (Thus the price of an elastic good is equal to its marginal value.)

*Rebuttal*: First of all, it is worth noting the obvious fact that the most elastic goods are essential goods (for example, water, food or, to a lesser extent, gasoline) and that if the state monopoly of country V, which has an average salary of 888 monetary units, sets prices for water in 1000 monetary units, then of course people will still have to buy water, but not from the state monopoly of country V, but from representatives of the black market, which will subsequently turn out to be suboptimal due to the growth of the shadow sector of the economy and public discontent.

Moreover, price curves are not hyperbolas, as is implicitly considered in Ramsey Pricing. In fact, price curves are a strange attractor in the corresponding phase space, since price trajectories can be stable along some local coordinates and unstable along other local coordinates in accordance with the rate of their changes; they can be sensitive even to minimal initial changes in the market if they grow rapidly during time. Since the price retains its properties even with small deformations of the differential, (the differential in economic science is the difference between the return on assets and the weighted average settlement rate), it serves as a mathematical image of dynamic chaos in the economy.

In other words, the solution to the Ramsey problem (what prices should a government monopoly charge for the various products it sells in order to maximize social welfare (the sum of producer and consumer surplus) while generating enough revenue to cover its fixed costs) comes from the Tax Theorem and is its special case, since in order to achieve the Pareto optimum, prices of state monopolies must be fixed at a consensus level until they diverge from internal market prices by a significant equivalent (for example, from 50%) and are sufficiently covering the cost of a relatively free market (in a non-crisis situation) on the same principle as the income tax in the Tax Theorem.

The Tax Theorem is also a prerequisite for the application (or at least a stimulant) of the Keynes-Ramsey rule, since with a differentiated scale of taxation due to the artificial degeneration of the market due to blocking healthy competition and an increase in the number of limiting factors, it is much more difficult for a person as an economic agent to distribute consumption into two periods, just as he chooses the proportion in which he divides his means into the consumption of two particular commodities.

#### The Tax Theorem and the Planned Economy

Opposition to the middle class is a criterion of economic leftism, since if in a left-liberal economy (conditionally average leftism) the middle class exists, but is under constant pressure, then in a planned economy (ultraviolet-leftism) the middle class is fundamentally impossible. The reason is that the middle class is the pillar of society in a complex sense, i.e. Representatives of the middle level of the financial system are not only those who can afford household appliances, an average-sized apartment, or throw away a good sofa to buy a new one that is even better. No, the middle class as an educated representative of the petty bourgeoisie is the core of the state, not only economically, but also socio-politically. In the middle class, a healthy nation is born as a cultural and political community; from the middle class, a healthy civil society begins, i.e. the middle class, as the most balanced and numerous element of a healthy economy, is its natural foundation, unlike all other strata.

#### The Tax Theorem and Future Tax Optimizations

Since the “tax question” - the issue of optimizing income taxation has been resolved, it is proposed to reform it into a theory of taxation, which will deal with further generalization of the Tax Theorem, the search for lemmas to it and the question of the proportion of direct and indirect taxes.

#### **Conclusion**

As part of this study, comprehensive analytical work was carried out, the purpose of which was to study the impact of the tax system and economic model on the state and opportunities of the middle class and the viability of free competition with progressive taxes. The presented material clearly demonstrates that the middle class, as an integral element of the economic and socio-political system of the nation, is of critical importance in ensuring the sustainable development of the state. At the same time, as has been shown, in a planned economy, the existence of a middle class turns out to be fundamentally impossible due to institutional and structural restrictions. And with a progressive tax scale in a market economy, both the middle class and competition itself are under threat. The Tax Theorem presents a new look at optimizing the tax system, offers a set of tools for more efficient distribution of the tax burden and closes the question of the optimal income tax scale.

However, additional research and modifications have been found to be necessary to integrate these principles into a broader economic context.

Thus, the results of this study can serve as a starting point for further study of the relationships between tax policy, economic model and socio-political structure. In particular, further research is needed to optimize the proportions of indirect and direct taxes in order to obtain a more complete picture of the influence of these factors on the state of the middle class and the stability of the economic system as a whole.

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附属责任的若干问题

**SOME PROBLEMS OF SUBSIDIARY LIABILITY**

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抽象的。本文讨论了与控制人(受益人)承担附属责任相关的问题。什么是“受益人”以及如何定义它。为了解决这个问题,作者试图了解这种现象的性质以及不仅在俄罗斯联邦境内而且在欧盟国家境内规范这一程序的现行法规。需要注意欧盟国家和俄罗斯联邦国家立法之间的差异。文章作者生动地指出了两种方式在确定受益人问题上的差异。名义上的比较可以作为俄罗斯立法完善的动力。

关键词: 受益人、债权人、最高法院、欧盟、客观破产。

**Abstract.** *The article discusses issues related to the problems of bringing controlling persons (beneficiaries) to subsidiary liability. What is a “beneficiary” and how to define it. To solve this issue, the authors tried to understand the nature of this phenomenon and the current regulations that regulate this procedure not only on the territory of the Russian Federation, but also on the territory of the European Union countries. Attention is paid to the difference between the legislation of the countries of the European Union and the Russian Federation. The author of the article colorfully points out the differences between the two approaches to the issue of determining the beneficiary. and the nominal comparison can serve as an impetus to the improvement of Russian legislation.*

**Keywords:** *beneficiary, creditor, Supreme Court, European Union, objective bankruptcy.*

As has already been noted by many authors in their scientific works in modern Russia, the greatest difficulties in implementing the mechanism of subsidiary liability are caused by the following categories:

- determination at what exact moment signs of true insolvency occurred;
- determination of who actually is the controlling person of the debtor.

Russian society saw the phrase “objective bankruptcy” for the first time in the ruling of the Supreme Court of the Russian Federation No. 347-ES28-1673 dated July 20, 2017. The definition of this phrase is given in case No. A49-6737/2015 as follows: “due to the declining value of net assets, the claims of creditors (at the same time for the payment of obligatory payments), the debtor cannot fully satisfy the claims of creditors.”

In its decision in this case, the Supreme Court of the Russian Federation issued Resolution No. 45, which stated that objective insolvency is the point in time when the debtor became unable to pay the financial claims of creditors, and the debtor cannot pay mandatory payments, since he has a total cost assets are less than debt.

Recently, the legal practice of the Courts when considering such cases refers to the definition of the above-mentioned resolution of the Supreme Court of the Russian Federation.

But here too there are difficulties. The meaningful difficulty lies in the fact that an acute question has arisen: it is impossible to accurately determine the point in time at which it is necessary to estimate the real value of the debtor’s assets.

It should be noted that quite a long time passes between the two events:

- the debtor has objectively become bankrupt;
- finding out the real value of the debtor’s assets (his property is searched and an inventory is carried out).

This period of time, in modern reality, can be more than three years.

Today, the legislator in his governing documents in relation to the term “objective bankruptcy”:

- did not define the phrase;
- did not identify its signs.

Based on the above, the above problem has become acute.

By tracking the practice of courts, we can conclude that this phrase is understood differently. And this is true, since in this matter all aspects matter:

- lack of assets;
- lack of property;
- presence of signs of insolvency;
- presence and extent of delays in payments to creditors;
- the amount of the debtor’s net assets;
- the reason for the fall in the price of the debtor’s assets on the balance sheet.

Moreover, it should be noted that the balance sheet only indicates general information about liabilities and assets for a certain month or year, and a smaller



value of assets compared to liabilities does not mean that the debtor cannot pay its creditors.

The Supreme Court of the Russian Federation indicated that each individual case is strictly individual, and it is simply necessary to consider its own circumstances in each case. And it is simply impossible to fit every case into a certain framework that will be prescribed in legislation.

And it is precisely this approach to the phrase that will ensure a clear indication of the criteria of the problem and, as a result, will increase the protection of the creditor before the debtor.

The United States of America has already faced this problem and solved it successfully. It was their courts that coined the term “checklist” tests. It is by these tests that the moment of onset of signs of true insolvency is determined. Moreover, in each specific state of the above country, this test is different. And it is precisely in this practice that the need to adopt one general “checklist” test can be traced. It is this experience of legal proceedings that the Supreme Court of the Russian Federation should take into account and determine its “checklists” test, in which it is necessary to explain the main criteria in relation to the issue of determining the occurrence of signs of insolvency.

In Russian legislation (Bankruptcy Law) there is a rule that allows reducing the subsidiary liability of a formal manager if this manager discloses an individual or other legal entity that receives money or other benefits from a benefactor. It is this provision of the Law that allows law enforcement agencies to facilitate the investigation of actions in the interests of creditors in order to bring the beneficiary to subsidiary liability.

This provision exists in the Law, but according to the Acting Head of the Federal Tax Service of the Russian Federation, it has not yet worked as a pre-trial deal with the state. In his statement, this official expressed the hope that it might work in the Criminal Law of the Russian Federation.

The experience of Western European countries (member countries of the European Union) is interesting. These countries maintain a register of beneficiaries. The first such list appeared in England on June 25, 2014 (a bill was passed, according to which a unified register of beneficiaries was created - PSC Register).

The main idea of introducing this register is to establish a vertical management of certain companies to establish the real beneficiary.

About a decade ago, the European Union passed a bill that was designed to combat illegal cash withdrawals and money laundering. This law in Western countries is known as the Fourth EU Anti-Money Laundering Directive (05/20/2015).

According to this Law, the beneficial owner of a company or organization is an individual if he indirectly or directly controls the activities of the company or has a participation share of more than 25 percent.

But in the European Union there is a practice where each state of this Union can lower the threshold for owning shares in a company.

But if an individual does not have a share of shares in the company, then the beneficiary is recognized as an employee of the company holding a senior management position.

But already for private foundations, trusts, and so on, the protector, general director, founder, trustee and similar managing person are recognized as the beneficiary. Moreover, this register is uniform in the countries of the European Union, and each of the participating countries must store it in an officially approved journal of the European Union. This requirement is specified in European Union Law.

But just three years later (06/19/2018), the following fifth law was registered in the official journal of the European Union, designed to combat illegal cash withdrawal and money laundering. It is registered under the name Anti-Money Laundering Directive (5AMLD).

This bill was registered in mid-2018, but began to work on January 10, 2020. This bill is intended to solve new problems discovered after the implementation of Directive 4 (Fourth EU Anti-Money Laundering Directive (05/20/2015)). It should be noted that the fourth directive came into effect in 2017, but was unable to provide for some issues related to illegal cash withdrawals and similar problems.

The Anti-Money Laundering Directive (5AMLD) describes that this edition is designed to respond to terrorist threats and their implementation in some countries of the European Union, such as England, Belgium, Italy, France and Finland.

But it should be noted that the Anti-Money Laundering Directive (5AMLD) has made absolutely no difference to either party in the penalties that are applied for identified violations. But it expanded the circle of persons responsible for the above violations.

The new fifth legislation (Anti-Money Laundering Directive (5AMLD)) ensures high transparency of the financial sector in the management of organizations and focuses specifically on the beneficial management of trust funds.

The data contained in the above register is already available to competent authorities, such as the Financial Conduct Authority (FCA), professional body supervisory authorities, bank authorities, European Union governments (any authorities that express a legitimate interest in the information). Along with the operational activities of the competent authorities, representatives of the free press and public figures can access this information, and there is no need to refer to the Law.

This is what creates an additional barrier to illegal cash withdrawal and money laundering by negligent business managers. This fact also creates transparency of the situation for a potential lender.

Moreover, if the interested person was not provided with the requested information on the beneficiary, then the official who did not provide it will incur

criminal liability in accordance with the laws of the country where the incident occurred.

Unfortunately, at the moment, a similar base of beneficiaries (controlling persons of a bankrupt enterprise) will not be introduced in the Russian Federation.

In the Russian Federation there is Federal Law No. 115-FZ “On combating the legalization (laundering) of proceeds from crime and the financing of terrorism” (dated 08/07/2001). It was to this Federal Law that on December 21, 2016, the Government of the Russian Federation introduced amendments, according to which a legal entity is obliged to provide information about its beneficiaries. These changes have been made to paragraph 6.1 of the above Federal Law. Moreover, according to this paragraph, the beneficial owner of the company is an individual who directly or through nominees owns more than 25 percent of the shares of the company, or controls directly or indirectly the activities of the company.

A legal entity about the beneficial owner must provide information in the following form:

- 1.full name;
- 2.citizenship;
- 3.date of birth;
- 4.residence address;
- 5.registration address;
- 6.SNILS number;
- 7.taxpayer number (if available).

According to the above Federal Law, information about the beneficiary is disclosed in the notes to the annual accounting report and to the financial performance report for the current period.

The Ministry of Finance of the Russian Federation in Order No. 48n dated April 29, 2008 On approval of the accounting regulations “information about related parties” (PBU 11/2008) established exactly the above procedure for disclosing the beneficial owner.

If, at the request of Rosfinmonitoring (an authorized body determined by the legislation of the Russian Federation), a legal entity does not provide information, or does not provide it in full, or distorts the actual beneficiaries, then the law enforcement authorities will impose an administrative fine:

- for officials in the amount of up to 40,000 rubles;
- for a legal entity in the amount of 500,000 rubles.

This is stated in the Code of Administrative Offenses of the Russian Federation in subparagraph 1, paragraph 25, article 14.

Analyzing all of the above, it is difficult to find beneficiaries in the Russian Federation, but all the tools for this action are all specified in the Laws (accounting statements).

All these tools are given to the creditor for a situation in which if the manager evades payment, the creditor himself could directly recover the debt from the beneficiary.

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保障法治秩序和国家安全过程中国家机关数字化法律规制问题的理论与法学研究

**THEORETICAL AND LEGAL STUDY OF THE PROBLEMS OF  
LEGAL REGULATION OF DIGITALIZATION OF THE INSTITUTE  
OF THE STATE IN THE PROCESS OF ENSURING LAW ORDER  
AND NATIONAL SECURITY**

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抽象的。文章对国家机构数字化进程中法律规制中法律关系客体规制过度、法律形式主义、权力关系公私利益难以关联等问题进行了理论和法理分析。事实证明，在制定反舆论操纵的方法时，国家数字化的法律规制过程与公众对此类活动的认可是相互关联的，这在未来既可以保护公民的权利和自由，又可以确保法律的实施。在公共政策和执法实践中有效使用数字技术。

关键词：国家数字化、法律数字化、法律秩序、法律文化、法律规制问题。

**Abstract.** *The article provides a theoretical and legal analysis of such problems in the legal regulation of the process of digitalization of state institutions as excessive regulation of objects of legal relations, legal formalism and difficulties in correlating public and private interests in power relations. It is shown that the process of legal regulation of the digitalization of the state is interconnected with public approval of such activities when developing methods to counter the manipulation of public opinion, which in the future will both protect the rights and freedoms of citizens and ensure law and order with the effective use of digital technologies in public policy and law enforcement practice.*

**Keywords:** *digitalization of the state, digitalization of law, legal order, legal culture, problems of legal regulation.*

One of the central problems in the modern theory of state and law is the transformation of state institutions under the influence of information and communication technologies. As part of the scientific search, researchers propose concepts,

doctrinal models, such as: legal service, service and network models of the state, etc., questions about the conceptual apparatus of the processes of modernization of the institution of state in the conditions of digitalization of social relations also remain debatable. One of the most relevant for research in the modern theory of state and law is the institution of «electronic participation», as a form of involving citizens, civil associations and civil society as a whole in the management of state affairs and providing a transformative impact on it. At the same time, in the absence of a unified conceptual apparatus, administrative and legislative barriers, as well as the lack of a high legal culture of citizens, significant problems arise in the legal regulation of the digitalization of state institutions.

In the modern information society, the idea of social justice takes the form of maintaining effective law and order under the strict supervision of civil society. Otherwise, the state acquires an anti-human character, which creates risks of its destabilization and degradation. Also B.A. Kistyakovsky wrote that «a person with his ideal aspirations and highest goals cannot put up with darkness, so that the state, which must realize the solidary interests of people, is engaged in extermination and destruction of them» [3, p.555]. In fact, the modern institution of the state is deprived of the opportunity to have anything other than the humanistic character of its organization, and although modern technologies create the potential for unprecedented control and intervention by the state in the personal lives of citizens, such control is not necessary for the effective functioning of the state and society. As a result, the only acceptable form of monitoring public relations in a modern state is assessing the effectiveness of maintaining law and order. E.V. Svinin writes that «the legal order makes it possible to judge not only the final results of the law, but can also be used for a qualitative assessment of legal regulation as a whole» [7, p.369]. These conclusions suggest that modern technologies can be used both to improve the lives of citizens and to improve the quality of public administration, one of the criteria of which is the maintenance of law and order and the implementation of legal law enforcement activities, which can serve as a universal way to assess the effectiveness of the legal policy of the state as a whole.

Improving legal instruments for maintaining national security is associated with the development of forms and methods of law enforcement. The modern rapidly changing world has shown the priority role of maintaining law and order while preserving and protecting the cultural diversity of society. At the same time, the practice of protecting national security cannot be considered effective without involving citizens in its implementation, which is associated with activities to form a high legal culture in them in the context of countering extremism and terrorism. Intercultural, interethnic and other social contradictions in the modern information society are becoming more and more unpredictable, which requires the improvement of universal methods for resolving them, which are legal in nature, and in the process of legal implementation activities acquire sociocultural features.

The effectiveness of legal policy to maintain national security is associated with the involvement of public authorities in dialogue with civil society. At the same time, commitment to pluralism and the acceptance of cultural, ethnic and social differences in society cannot be characterized as a homogeneous phenomenon, which requires from public institutions a wide range of cultural and educational activities to overcome emerging contradictions that serve as sources of tension, social and political disorganization and destabilization. The priority in this direction is to work with youth and ethnic minority groups in the state. O.I. Kuskarova writes that «the education of tolerance in human relations, the formation of a mentality of tolerance is the most important strategic task of education in the 21st century. Work on developing tolerance in children and adolescents, its success largely depends on the social conditions in which the child lives. In this, a large role is given to the family, where values and norms are of great importance in the formation of personality. In addition, «intolerant» adults (parents) are not able to raise a tolerant personality. It is the formation of tolerant attitudes of parents, taking into account the state of modern society, that is a necessity at the present stage of development of society» [4, p.161]. Thus, in the process of overcoming the risks of the development of extremism and terrorism, as one of the main threats to national security, a significant role should be given to the development of the institution of family in the state, the maintenance of traditional values, and educational activities on promising forms and methods of education.

Another important factor in maintaining national security in the process of digitalization of public relations is the transparency of political and legal processes in society and the state. Despite the undoubted advantages of citizens' ability to control the activities of public institutions through digital technologies, public opinion can be susceptible to populism, as well as misled by «social engineering» technologies, which can have a destructive effect on the stability of the institution of the state. G.G. Shinkaretskaya, A.M. Berman write that «today, extensive work is being carried out both at the state and non-state levels for the development of digital technologies and their widespread penetration into all spheres of society - investing in the development of the national IT sector, financial incentives for the creation of the latest information technologies, cooperation for their creation at the international level, stimulation of investment and entrepreneurial activity in this area, etc.» [5, p.258]. In such conditions, it is obvious that maintaining national security through legal methods must be combined with the development of applied law enforcement tools, as well as maintaining a high level of trust in the activities of public authorities in the digital space.

In the process of using digital technologies to improve the standard of living of citizens, large-scale transformative processes are taking place in law and the state, where either existing rules are applied «by analogy» to new legal relations,



or completely new legal acts are being developed based on the doctrines and concepts of the digital policy of the state, such as Strategy for the Development of the Information Society in the Russian Federation for 2017 – 2030, approved by Decree of the President of the Russian Federation of May 9, 2017 No. 203 [6]. This development strategy allows the legislative and executive authorities to optimize legislation, which contributes to the intensification of the use of technology in socio-economic and political processes, which is one of the priorities of state development, as indicated in paragraph 12 of the strategy. At the same time, this optimization cannot be characterized as an effective process, since the transition to digital methods of regulating public relations occurs through the adoption of additional legal acts, formal «digitization» of bureaucratic processes of executive authorities and problems in the legal implementation of adopted norms. As a result, it can be stated that the problems of legal regulation of digitalization of state institutions are associated with excessive regulation of objects of legal relations, legal formalism and difficulties in correlating public and private interests in power relations. The need to highlight these problems in the processes of legal regulation of digitalization processes is associated with the unpreparedness of public authorities for the onset of the digital era and its rapid development in the absence of legal control. As a result, the legal policy of the state began to acquire the features of excessive regulation with insufficient quality of law enforcement, which contains risks of violating the rights and freedoms of citizens.

The problem of excessive regulation of social relations in the information society is associated with the impossibility of influencing objects of regulation in the digital space using standard legal methods of coercion. On the one hand, this process is designed to protect society and the state from challenges and threats to public stability and national security, but on the other hand, it harms the economic sector, criminalizes potentially promising forms of economic activity and reduces the competitiveness of the state in the international arena. Currently, one of the ways to overcome the emerging contradiction is the so-called «regulatory guillotine», the essence of which is the abolition of standards and other administrative legal requirements for business if they have a negative impact on it. At the same time, researchers emphasize that this measure is temporary, designed to compensate for the imperfections of legislation that is not adapted to modern socio-economic reality. O.I. Chepunov writes that «the process of implementing control and supervisory reform depends on the ability of the expert community, working groups and regulatory bodies to ensure high-quality and prompt implementation of assigned tasks under the leadership of the Ministry of Justice» [1, p.140]. At the same time, overcoming the excessive legal regulation of modern relations is impossible without a large-scale administrative reform, in which representatives of economic activity must necessarily participate, which will allow the development of standards and norms adequate to reality.

The possibilities of digitalization of public authority are directly related to the development of legal culture among civil servants. One of the significant directions in the conditions of excessive regulation of these processes is the formation of an idea of the internal content of the law and the priority of protecting the rights and freedoms of citizens in the process of their application. Legal formalism in law enforcement practice is a dangerous trend that will not allow the full implementation of effective dialogue between the authorities and citizens on governance issues. At the same time, the formal approach does not need to be excluded from law enforcement practice, since law, being a universal regulator of social relations in the case of controversial interpretations, allows us to protect and preserve the integrity of the social system and support its functioning. For example, I.S. Ilyin writes that «A formal attitude towards the legal law is the only guarantor of its safety and its effective implementation» [2, p.5]. Thus, an effective approach to the formation of the legal culture of civil servants should combine the education of respect for the «spirit» of the law while strictly following it based on the literal interpretation of the wording.

Legal formalism is widespread both in law enforcement activities and in carrying out reforms of public authorities. The digital space can be characterized as areas where many types of activities are poorly subject to legal regulation, but in order to declare the protection of the rights and freedoms of citizens, prohibitive measures are still applied against them, which does not stop their activities, but, on the contrary, serves as a catalyst for their criminalization. In this case, formal measures replace the search for effective tools for legal implementation, where legal norms must be correlated with the technological capabilities of their application. When carrying out the digitalization of public authorities, it is important to ensure not only the formal possibility of using e-government tools, but also to create comfortable conditions for citizens to use websites, applications and other tools.

The problem of harmonizing public and private interests in power relations haunts the institution of the state even before the formation of the information society. The peculiarity of the emergence of digital technologies is their speed and broad transformative potential. As a result, public authorities and citizens were unable to form a common understanding of the forms and methods of using them in the system of checks and balances, as well as in the dialogue between authorities and citizens. As a result, digital technologies have been integrated into society chaotically, modifying both it and the criteria for the legitimacy of society's representation in power. Currently, a public consensus is being formed about the opportunities and risks of using technology in the legal policy of the state, which lies in the need to maintain law and order and reform the legal system, taking into account the constitutional rights and freedoms of citizens while overcoming legal formalism and reducing the possibility of abuse of rights in law enforcement activities.

As a result of the theoretical and legal study of the problems of legal regulation of digitalization of state institutions in the process of ensuring law and order and national security, it was established that they are associated with excessive regulation of objects of legal relations, legal formalism and difficulties in correlating public and private interests in power relations. Taken together, this leads to difficulties in integration processes, the criterion of effectiveness of which is the level of citizens' trust in the authorities. The problem of increasing the level of citizens' trust in government is associated with the growing opportunities for transparency in the digital space, as a result of which citizens receive opportunities for public control over the activities of government bodies and officials. This process is not exclusively positive, since it contains risks of destabilizing society through manipulation of public consciousness, the creation of «information noise», «social engineering», etc. As a result, the process of legal reform of the state and society becomes associated with public approval of such activities in the development of methods to counter the manipulation of public opinion, which in the future will both protect the rights and freedoms of citizens and ensure law and order with the effective use of digital technologies in public policy and law enforcement practice.

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联邦国家教育机构“克孜勒总统学员学校”教师数字素养形成方法支持的特点  
**FEATURES OF METHODOLOGICAL SUPPORT FOR THE  
FORMATION OF DIGITAL LITERACY OF TEACHERS IN THE  
FEDERAL STATE EDUCATIONAL INSTITUTION “KYZYL  
PRESIDENTIAL CADET SCHOOL”**

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抽象的。教育系统的数字化转型不仅对整个教育过程产生影响，而且对教学人员的要求不断变化。现代教师必须“跟上”信息技术的发展，努力通过积极利用ICT技术和数字资源来提高工作质量；这要求他具备高素质、精通信息技术以及媒体和信息素养。此外，根据专业标准，现代教师必须具备信息通信技术能力，既包括对信息技术的熟练程度，也包括对信息技术在教育过程中的应用方法的熟练程度。因此，现阶段的教育体系需要教师不断专业发展，而数字环境下教师活动的方法论支持，考虑到教育现代化的现代趋势，是构建有针对性的教育模型的关键工具。在识别专业缺陷的基础上提高他们的资格，并确保在教育过程中有效和舒适地使用信息和通信技术、数字工具。文章介绍了克孜勒总统学员学校教师数字素养（能力）形成过程中获得方法支持的经验。

关键词：教师、数字化、媒体和信息素养、数字素养、ICT 技术、方法支持。

**Abstract.** *The digital transformation of the education system has an impact both on the educational process as a whole and on changing requirements for teaching staff. A modern teacher must “keep up” with the development of information technology, strive to improve the quality of his work through the active use of ICT technologies and digital resources; this requires him to be highly qualified, fluent in information technology, and media and information literacy. In addition, in accordance with the professional standard, a modern teacher must have ICT competencies both at the level of proficiency in information technologies and at the level of proficiency in methods of their application in the educational process. Therefore, the education system at the present stage requires constant professional development of teachers, and methodological support for the activities of teachers in the digital environment, taking into account modern trends in the modernization of education, is a key tool for building a targeted model for improving their qualifications, based on identifying professional*

*deficiencies, and ensuring the effective and comfortable use of information and communication technologies, digital tools in the educational process. The article describes the experience of methodological support in the formation of digital literacy (competence) of teachers of the Kyzyl Presidential Cadet School.*

**Keywords:** *teacher, digitalization, media and information literacy, digital literacy, ICT technologies, methodological support.*

The education system of our country is developing in the context of global digital transformation, and the National Doctrine of Education of the Russian Federation until 2025 clearly outlined the main strategy, tasks of modernization of modern education, the main paradigm of education: “education is not for life, but through life.” A modern educational institution has gone through a rapid process from computerization, informatization to digital didactics, the creation of a unified information and educational environment (UIEE), which is considered as one of the conditions for achieving a new quality of education in the context of the implementation of the Federal State Educational Standard, a quality that meets the modern socio-economic development of Russia in the conditions globalization and world digitalization.

Teaching staff are the basis and main resource of education, therefore, the effectiveness of the functioning of the entire educational system depends on teaching staff, their potential, and ability to effectively solve problems to ensure the quality of education in a rapidly changing modern world.

Based on the statement of RAE Academician A.A. Leontyev “A functionally literate person is a person who is able to use all the knowledge, skills and abilities constantly acquired throughout life to solve the widest possible range of life problems in various spheres of human activity, communication and social relations” [1], we can conclude that To effectively perform basic functions, a modern teacher, a professional teacher, needs to have special pedagogical abilities, not only didactic, communicative, design, organizational, academic, suggestive, perceptual, expressive, applied, but also the ability to enter into relationships with the external environment as quickly as possible adapt and function in it, that is, be functionally literate.

In the context of the digital transformation of education, the introduction of a professional teacher standard, the issue of media and information literacy is one of the most important topics in modern pedagogy. Based on the works of modern scientists, it can be argued that media and information literacy is a key competency of a modern teacher. Until now, there is no clear definition of a teacher’s media and information competence, although a description can be found in the pedagogical literature in many works of modern scientists. The basic definition is given by UNESCO. In 2010–2013, UNESCO and IFLA integrated two concepts – “media lit-

eracy” and “information literacy” – into a single whole – “media and information literacy”. “Media and information literacy is “a set of attitudes, knowledge, skills and abilities that allow a person to determine when and what information is required, where and how it can be obtained, how it should be assessed, systematized and used in accordance with legal and ethical standards”. [2] Thus, we should no longer talk about information and communication technologies, computer literacy, but also media and information literacy, but in general, about the digital literacy of a modern teacher. With the introduction of professional standards, the role and importance of media education for teaching staff is also being updated.

In the Federal State Government Educational Institution “Kyzyl Presidential Cadet School” (hereinafter referred to as the Kyzyl PCS), a unified information and educational environment has been created, which includes a set of technical means, a complex of information educational resources, including digital educational resources; a set of technological means of information and communication technologies: computers, multimedia equipment (computer, projector, interactive whiteboard), software, various databases; a system of modern pedagogical technologies that provide training in a modern information and educational environment; operating on the basis of common principles and according to general rules that ensure information interaction between teachers, cadets, parents, the public, as well as meeting their information needs.

Teachers of the Kyzyl PCS strive to improve the quality of education through the active use of modern educational technologies, including information technologies, they undergo constant training and improve their qualifications, continuously educate themselves and improve themselves. To increase the competence of teachers in solving educational, cognitive and professional problems using information and communication technologies (ICT), digital electronic resources, modern multimedia and computer technology, mentors represented by experienced professionals and the methodological service of the school are recognized.

In the Russian Federation, only in December 2020 did a “reboot” of the methodological service begin, when by order of the Ministry of Education of Russia the Concept of creating a unified federal system of scientific and methodological support for teaching staff and management personnel was approved, and in the Federal State Government Educational Institution “Kyzyl PCS”, as in all pre-university general education Institutions of the Russian Ministry of Defense have a methodological service, methodologists of the educational department, department of educational work, laboratories of technical teaching aids and laboratories of innovative educational technologies. This distinctive feature from other general education institutions allows us to organize work on the professional growth of teachers at a higher, systematic and quality level.

Methodological support is a specially organized process aimed at overcoming the professional and personal problems of a teacher, which includes a system of pedagogical events and situations.

The result of this process is the understanding of the teacher's professional experience, actualization of self-development, professional success, personal development [3]

The process of methodological support of pedagogical activities in the digital educational environment is aimed at increasing the efficiency of the use of IC technologies and digital teaching aids in the educational process as the main goal of the professional activity of the methodologist and is implemented by solving the following tasks:

- creation of a unified information educational space, a safe infrastructure of the educational environment;
- supporting the activities of teachers in the development and implementation of digital teaching tools;
- systematic study, generalization and dissemination of best practices in the use of digital technologies in teaching practice;
- participation in the formation and development of digital literacy among teachers based on identified professional deficiencies.

Professional growth of teachers occurs through the implementation of an individual professional educational route, in accordance with professional deficits.

In the context of the implementation of a modern in-school model of scientific and methodological support for the professional and personal growth of teachers at the FSGEI “Kyzyl PCS”, until 2025, teachers are engaged in self-education, are involved in corporate training, in the competitive movement, visit methodological departments in their areas, and participate in the work of creative groups. The school's methodologists develop methodological recommendations, manuals, and instructions to help teachers.

Methodological support for the formation of digital literacy of teachers in the Kyzyl PCS is built in accordance with several groups of professional deficits, which are determined on the basis of diagnostics, self-diagnosis and monitoring. Despite the high level of development of the majority of digital literacy teachers, we identify some groups of professional deficits: insufficient practical skills in working with an interactive complex, an interactive whiteboard; inability to prepare information for the news feed of the official website of the school, lack of ability to critically analyze text, search for information on the global Internet; functional literacy is insufficiently developed (the ability to highlight the relevance and innovativeness of one's activities, write a scientific article on a professional topic), practical teachers with extensive work experience find it difficult to write a written description of their experience, the low degree of development of

ICT competence does not allow them to find and evaluate quality of digital educational resources, choose the right electronic licensed publication for publishing your work experience.

Methodological support is carried out in several directions; we will dwell on some of them.

Providing practice-oriented assistance when working with computer equipment, technical teaching aids and the use of digital educational resources (DER), in addition to the main tasks, the tasks and implementation of SanPin when working with computer equipment, and the use of health-saving technologies are solved. (The Program for working with interactive whiteboards and SMART Boards is being implemented, Instructions have been published, and seminars have been held).

Formation of information culture through the preparation of information materials for the official website of the school. The website is an essential element of the information policy of a modern educational institution and a tool for solving a number of educational problems related to the formation of information culture. The ability to work with information develops critical thinking, helps in working with information on the global Internet. (methodological recommendations have been prepared, instructive and interactive training seminars - workshops, classes - are conducted).

Methodological support for the generalization and dissemination of pedagogical experience, including in scientific forms: publications in the media, publication of articles, theses in collections of scientific and practical conferences, has two vectors. The first is traditional methods of methodological support - training seminars, group and individual counseling, methodological recommendations were prepared. The second non-traditional direction is supervision. Supervision of the acquisition of necessary competencies, new experience and awareness of new opportunities in teaching activities. The concept of "supervision" appeared in pedagogy quite recently. Supervision has come a long way and continues to develop not only abroad, but also in Russia; this problem is studied in the works of L.V. Gavrilova, M.Yu. Kraevoy, O.V. Lukyanova, A.V. Molozhavenko, M.N. Pevzner, N.O. Yakovleva and others.

According to E.V. Yakovleva, "supervision" in the educational field is a process of pedagogical support aimed at subjects who already have experience in practical activities, but need professional help and support. [4].

It is natural that in modern realities methodological services are also being transformed, the functions of the methodologist and his role are changing, from mentor, tutor to supervisor. A teacher who constantly supervises his activities takes a stable, responsible position in relation to the results of his work, does not burn out emotionally, develops quickly professionally and remains motivated for



further work, since in the supervision format, not only his professional, but also and personal interests.

Thus, methodological support for the formation of digital literacy of teachers in the conditions of a pre-university general educational organization of the Ministry of Defense of the Russian Federation, in the conditions of a unified, including electronic information and educational environment of the school, allows teachers to acquire the necessary competencies, engage in innovative activities, improve their professional level, gives awareness of new opportunities in teaching activities, since the teacher has always been and is the main, key figure in national education, and in general, a highly professional and results-oriented team.

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培养大学生知识图谱能力的经验：心理和教学方面

**EXPERIENCE IN FORMING UNIVERSITY STUDENTS' ABILITY  
TO MAP THEIR KNOWLEDGE: PSYCHOLOGICAL AND  
PEDAGOGICAL ASPECTS**

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抽象的。寻找有效的教学方法，唤醒学生对所学知识领域的兴趣，鼓励学生独立学习和分析信息，并使其更持久地同化，是教学法的主要任务之一。知识图谱是用图形方式展示与某一知识领域相关的概念与概念之间的联系，目的是让学生形成关于该知识领域的系统思维。该报告描述了在一所医科大学教授的许多心理学学科的课堂上使用这种方法的经验。绘制知识心智地图是一个将信息系统化的多阶段过程。考虑了创建知识心智地图的工作阶段。已经确定的是，首先地图主要是对所研究的主题领域的现象学描述的结果，并且地图本身可能由几个不相关的片段组成。然后，随着教育材料的掌握，地图被详细化，并补充了对关键概念和概念的实证描述分析的结果，并将不相关的片段组合成一个图表。由于学生的知识是逐渐发展的，因此绘图过程总是迭代的。修改的频率表明作者对教育活动的动机和对学科的兴趣的表达程度。相反，地图长时间没有变化可以被认为是缺乏认知兴趣的标志，其编译器存在情绪倦怠综合症。作者的活动受到元认知过程的影响，元认知过程决定理论知识的自我评估、独立工作技能的形成及其规划。地图上有个人和小组工作的特点，作为巩固、测试知识和识别学科中发展不足的部分的工具。

关键词：知识系统化、知识图谱、概念和概念的心智图谱、知识图谱教学方法、个体和群体图谱。

**Abstract.** *The search for effective teaching methods that awaken students' interest in the field of knowledge being studied, encouraging independent study and analysis of information, and its more durable assimilation is one of the main tasks of didactics. Knowledge mapping is a graphical display of connections*

*between concepts and concepts that relate to a certain area of knowledge, with the aim of forming systematic ideas about it among students. The report describes the experience of using this method in classes in a number of psychological disciplines that are taught at a medical university. Drawing up mental maps of knowledge is a multi-stage process of systematizing information. The stages of work on creating mental maps of knowledge are considered. It has been established that at first the map is dominated by the results of a phenomenological description of the subject area being studied, and the map itself may consist of several unrelated fragments. Then, as the educational material is mastered, the map is detailed, supplemented with the results of an empirical-descriptive analysis of key concepts and concepts, and unrelated fragments are combined into a single diagram. Since students develop their knowledge gradually, the mapping process is always iterative. The frequency of changes made indicates the degree of expression of the author's motives for educational activities and interest in the academic discipline. On the contrary, the absence of changes in the map for a long time can be considered as a sign of a lack of cognitive interest, the presence of emotional burnout syndrome in its compiler. The author's activity is influenced by metacognitive processes that determine the self-assessment of theoretical knowledge, the formation of independent work skills, and its planning. There are features of individual and group work on the map as a tool for consolidating, testing knowledge, and identifying insufficiently developed sections of the academic discipline.*

**Keywords:** *systematization of knowledge, knowledge mapping, mental map of concepts and concepts, methods of teaching knowledge mapping, individual and group maps.*

**Formulation of the problem.** The search for effective teaching methods that awaken students' interest in the field of knowledge being studied, encouraging an active search for information, its independent analysis, and, consequently, more durable assimilation is one of the main tasks of didactics. Knowledge mapping is a graphical representation of connections between concepts and ideas related to a certain area of knowledge, with the goal of forming systematic ideas about it among students.

Novak J.D. and Cañas A.J. [9] consider conceptual knowledge maps (there are different names in the literature) to be an effective way to assimilate information. Positive experience has been accumulated in their use in the study of natural, social and human sciences [8], including in the study of biology [7], diagnostics in medical school [4,7,10], and the development of students' analytical abilities [4].

According to the authors [10], the transition to a systematic perception of educational material goes through several stages: (1) "Brainstorming" during the first acquaintance with the educational material; (2) "Organizational" stage; (3)

“Map layouts”: (4) Clarification of connections between pieces of information; (5) “Outcome Assessments”; (6) Corrections of inaccuracies and improvements to the map; (7) “Formation of a unified concept”; (8) “Meaningful learning” of the discipline.

**Methods.** In order to study the method of mapping concepts and concepts, we conducted a theoretical analysis of the literature on this issue. The experience of using the concept mapping method in practical classes in a number of academic disciplines, which are taught at different faculties of a medical university, is summarized. We use this method in practical classes in psychological disciplines taught at different faculties: “Psychology of Communication”, “Psychology of Social Work”, “Developmental Psychology”, “Pedagogy”. The experience of their use in practical classes in a number of clinical disciplines is summarized.

During practical classes and during self-study, students on their gadgets compiled and improved maps of concepts and concepts in the discipline being studied. At the end of each month they send the current version of the map to the teacher’s email. At each practical lesson, one or two students gave brief reports on the work done, demonstrated working versions of their maps, and talked about their general vision of the structure of the discipline and the difficulties they encounter when drawing up a map. Most students worked in the XMind software environment. This tool allows you to build graphic images of maps of various types and convey the individual characteristics of perception of the subject area being studied.

**Results.** According to our observations, the initial version of the concept map is characterized by polycentrism, the degree of which reflects the level of theoretical preparedness of the author. The influence of professional interests is also noticeable, as can be seen from the different levels of elaboration of different topics discussed in class and independently. The first versions of the map often represent a phenomenological description of one’s own life experience, reflecting the degree of involvement in the educational process, professional orientation and interest in certain sections of the educational material.

Maps of students interested in the discipline being studied are highly detailed, especially those sections that are of great interest to them. The different depth of knowledge of individual modules of the curriculum gives rise to disproportions in the representation of educational material in the map. In some cases, such distortions indicate difficulties that students have in mastering certain topics; in others, they reflect the professional interests of the teacher himself, who spent more time on his favorite topic.

The identified distortions in the representation of educational material in the maps of modules become the basis for the teacher to make adjustments to the distribution of educational (classroom) time in favor of insufficiently studied material.

As a result of the amendments made by the student, the map may undergo significant changes, which may improve it or aggravate distortions, violating the original logic of the information description, and shift the emphasis to unimportant facts. The teacher should control the introduction of amendments and the extent to which they correspond to the goals of the work on drawing up the map. Analysis and changes in the structure of the map often make it possible to identify existing knowledge gaps [6]. In this regard, not only the identification, but also the categorization of existing relationships is of great importance. Their understanding becomes a guideline for building chains of sequences of key provisions. Clarification of their hierarchy determines the choice of the level of detail of information in the map.

Examples from the teacher's practical experience help to assimilate, remember complex concepts, and establish connections between them. Explaining the educational material using these examples allows you to better understand the practical significance of the theoretical concepts. When discussing cases, multisensory didactic methods of presenting them are preferable.

An important sign of the integrity and consistency of students' ideas is the student's ability to transfer the principles of organization of one psychological mechanism to another. Analogical transfer is an extremely important skill when creating mental maps of knowledge.

**Discussion.** As they master the educational material, students' maps are replenished with the results of an empirical-descriptive analysis of key concepts and concepts. The structure of the map is increasingly influenced by ideas about the level of development of each section of the subject area being studied. The gradual accumulation of knowledge by students explains why the process of drawing up concept maps is iterative and is accompanied by a transition from fragmentary, fragmentary to systematic perception of educational material.

The teacher's assistance should gradually be replaced by independent work of students. The creation of knowledge maps is greatly influenced by metacognitive processes: personal characteristics, strategies of social behavior, developed skills in educational activities. These higher-order mechanisms regulate and control cognitive activity, determine the goals of educational activities, select information, control the progress of work, develop attention, and form an adequate self-esteem of one's capabilities.

Drawing up knowledge maps requires the creation of certain conditions:

- organizing reliable feedback from students to the teacher and each other, which creates the opportunity for regular consultations with group discussion of the progress of the task;
- regular monitoring of students' educational activities, encouraging positive dynamics in their work and requiring the elimination of existing shortcomings, making corrective changes in the educational process;

- holding round tables and final conferences with hearing student reports and reports, demonstrating concept maps and concepts.

The teacher can choose individual or group work for students. Preparation of individual cards develops independence in decision-making and the ability to organize one's educational activities. The quality of individual maps can be assessed by the similarity of their structure to generally accepted conceptual ideas about the subject area at the time of its consideration. For this purpose, student maps can be compared with a reference map compiled by a teacher or a group of experts.

Creating a map with a group of students usually takes longer. To ensure coordinated work and reduce the time for its creation, it is necessary to achieve a common understanding among group members of the goals of completing the task, a clear distribution of responsibilities that excludes duplication of functions, and coordinated activities of all group members.

To ensure compatibility between parts of the map made by different people, a unified plan of action is needed. Therefore, all team members should be provided with detailed guidelines for drawing up maps and standard templates for their compilation. The work of the team must be constantly coordinated by the leader, especially in the case of remote collaboration, both in real time and delayed. It is important for all team members to create and maintain a favorable, inclusive psychological environment that allows them to freely exchange opinions and ideas, and quickly reach consensus when making decisions and resolving conflicts.

Joint activities develop skills of collective creativity, mutual assistance, and supporting each other. However, each team member must be personally responsible for fulfilling the assignment given to him. The group leader needs to take into account the individual characteristics of each person and personalize the learning process. Taking into account and addressing individual needs, interests, style of learning activities, and the ability to adapt to the conditions of joint learning increases the level of educational motivation.

The positive aspects of group work on concept mapping are:

- mutual enrichment of personal knowledge and experience, which contributes to the creation of a more meaningful, complete, informative map;
- stimulation of creativity that generates synergy, the birth of qualitatively new ideas, the creation of a knowledge map with an innovative component;
- quick detection of erroneous judgments, biased attitudes, mistrust, prejudices, which, when working in a group, are easier to correct and replace with reliable information;
- deepening knowledge, greater confidence in one's competence.

The negative aspects of group work on mapping are:

- the need for additional efforts aimed at coordinating the activities of a whole group of people, especially in the absence of a clear distribution of roles and reliable communication channels;

- increased tension in the group, the likelihood of disagreements and conflicts.

For individual and group mapping, software products such as Notion, Obsidian, Evergreen, XMind, MindMeister, MindManager, Lucidchart, Coggle, etc. can be used. There are also network resources (Wikipedia, collective notes, etc.) that allow you to work on compiling knowledge maps remotely [11]. The use of computer technology and network resources can significantly reduce the time needed to create a map. Special learning platforms and software can be customized taking into account the individual characteristics and preferences of the student, creating a personalized learning environment that allows him to work at a pace convenient for him, with teaching material that matches the level of preparation of each student.

There are different options for working with concept maps. Thus, students may be given an incomplete map, where they should make additions from a pre-prepared list of concepts. It is more difficult to create a knowledge map from a list of concepts from a “blank slate”. Even more challenging is creating a knowledge map with only one key concept.

Novak J.D., Cañas A.J., [9], Bershinsky M.E. [2] believe that providing students with a list of initial concepts makes the task slightly easier, but limits their creativity.

Difficult-to-understand material can be divided into categories according to the degree to which students are familiar with it. This will make it easier to make connections and increase memory productivity. At various stages of formation, the pace of formation of knowledge mapping techniques may change. Periods of apparent stagnation in their development are caused by the accumulation of necessary information and work experience. Next, there may be a rapid transition to qualitatively more advanced ways of working [5].

The use of certain didactic methods of work does not exclude the possibility of their combination, which often gives the best result. Flexibility in choosing methods of conducting classes, taking into account the needs and interests of students, and the practical orientation of projects speeds up the creation and improvement of concept maps and concepts.

**Conclusions.** 1. Theoretical analysis of the literature and our own observations indicate the effectiveness of knowledge mapping, drawing up individual and group maps of concepts and concepts to consolidate and test students' knowledge. Mapping concepts and concepts facilitates the assimilation of educational material and accelerates mastery of it, which is noted when studying a wide range of special disciplines.

2. Metacognitive mechanisms of cognitive activity play an important role in the development of skills for effective concept mapping. Accelerating work on a mental map of knowledge is associated with the development of skills such as



planning one's activities, adequate self-assessment of one's capabilities, in particular, theoretical knowledge, and skills of independent learning activities.

3. Empirical observations and analysis of students' educational activities confirm the effectiveness of the method of mapping concepts and concepts, drawing up individual and group maps of educational material in psychological disciplines, which are taught to students of a medical university.

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彼尔姆剧院“U Mosta”制片人的人类学策略  
**THE PRODUCER'S STRATEGY OF THE PERM THEATER 'U MOSTA' IN AN ANTHROPOLOGICAL ASPECT**

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抽象的。 本文致力于反思彼尔姆话剧《U Mosta》的制片人谢尔盖·费多托夫 (Sergei P. Fedotov) 的创作方法, 涉及一般文化和当代人文学科中尖锐的艺术人类学问题, 尤其。 这项研究的新颖之处在于它使用了一种基于哲学、艺术研究、美学和符号学范畴的综合文化学方法。 本研究的目的是通过对两部戏剧的分析, 探讨制片人 S.P. 费多托夫在对人物形象及其价值观的风景演绎中所实施的策略。 研究结果如下: 进行的分析表明, SP·费多托夫的研究兴趣主要是对人类学灾难中人的精神命运进行艺术探究, 并始终致力于在舞台上形象地体现他对人的艺术和哲学概念。 他的导演的策略。

关键词: 导演策略、SP·费多托夫、彼尔姆剧院“U Mosta”、哲学人类学、艺术人类学、存在选择、自由与责任问题、寓言、神话。

**Abstract.** *The article is devoted to reflection on the creative method used by Sergei P. Fedotov, the Perm producer of the drama theater “U Mosta”, in terms of a problem of anthropology of art acute in culture, in general, and in the contemporary Humanities, in particular. The study is novel in that it uses a comprehensive culturological approach based on the categorial apparatuses of philosophy, art studies, aesthetics, and semiotics. The purpose of the study is to examine the producer’s strategy implemented by S.P. Fedotov in scenic interpretation of the image of a person and their values using the analysis of two plays. The results of the research are the following: the conducted analysis shows that SP Fedotov’s research interest in artistic inquiry into a spiritual destiny of a person in the anthropological catastrophe and consistent endeavor for figurative embodiment of his artistic and philosophical conception of man on the stage dominates his director’s strategy.*

**Keywords:** *director’s strategy, SP Fedotov, Perm theater “U Mosta”, philosophical anthropology, anthropology of art, existential choice, problem of freedom and responsibility, parable, myth.*

The Perm “Theater at the Bridge” is a creative organism that has no analogues, possessing unique practical and aesthetic experience, developing the best traditions of the Russian and European stage of the 20th century, having absorbed the experience of K.S. Stanislavsky, E.B. Vakhtangov, M.A. Chekhov, N. Evreinov, A. Artaud, E. Grotovsky, A.A. Vasilyeva. Director S.P. Fedotov, following his creative method, works with actors extensively, aiming to achieve live truth on stage, to comprehend the author’s ideas, and to continue and develop the concept of psychological theater enriched with the desire to explore the metaphysics of human characters and the true mystique of reality. The Perm Theater “At the Bridge” is a living world that has its own theatrical nature, existing according to certain aesthetic laws, subordinated to the main purpose of art - the study of man. A set of performances staged by S.P. Fedotov, starting from the founding of the theater (1992), and over the course of thirty years of its dynamic development, represents an original artistic reality, which has its own conscious directorial logic, its own aesthetic patterns, cross-cutting themes, theatrical techniques, artistic types, symbols and generalizations. Many of them echo each other; reflect one another, deepening from performance to performance. The appearance of a holistic figurative unity is given to the Perm Theater “U Mosta” by anthropological motifs that are repeated from performance to performance. General collisions are organically connected in the repertoire policy of S.P. Fedotova’s appeal to the material of modern drama and classics (N. Erdman, N. Sadur, M. Bulgakov, F. Dostoevsky, V. Shakespeare, N. Gogol, A. Ostrovsky, A. Pushkin, A. Chekhov, M. McDonagh, M Saltykov-Shchedrin, A. Vampilov, C. Dickens, D. Kldiashvili, K. Kesey). The director’s strategy of the Perm Theater “At the Bridge” is implemented as a synthesis of meanings and values in the aspect of artistic anthropology. Our article is a micro-study of the director’s strategy of the Perm Theater “U Mosta” in its anthropological content, with the goal of understanding its artistic foundations. This general research setting focuses our attention on the director’s methodology of S. Fedotov - to interpret the behavior of a stage character in a situation of existential choice. The theater is focused on revealing to the viewer the worldview and worldview of the persons acting on stage: sociocultural, psychological space; natural, historical, existential time; Eternity; God. It is through man, through his existence, that the connection between the mystical, Divine, and empirical, human (= profane) horizons of existence is realized in the artistic world of a dramatic performance. The interpretation of man as the focus and container of the metaphysical dimension of the world, on the stage of the only “mystical” theater in modern theatrical culture, as S.P. positions it. Fedotov in his public statements [1, 20], makes a person the central link of his directorial strategy. From the point of view of philosophical anthropology, from Aristotle, I. Kant to M. Scheler, E. Fromm, P. Tillich, “man, his subjectivity are defined as the main problem of study” [2,

35]. We are talking about the study of a subject, a person with his own attitude, self-awareness, inner life, and the drama of all human relationships. The question of “how personality is built in characters is central in artistic anthropology” [3, 60] and when considering anthropological problems of theater (in the theories and theatrical practices of M. Chekhov, N. Evreinov, E. Grotovsky). What distinguishes modern dramatic theater as truly human, truly human, that is, what is the ontological given of man in the artistic world of the dramatic performance of the Perm Theater “At the Bridge” (“human, too human”, according to the formula of F. Nietzsche [4]) - this one side of the problem. The other is associated with the aesthetic refraction of the human psychological type into an artistic stage image. Consideration of these issues using the example of an analysis of two performances of the Perm Theater “U Mosta” constitutes the content of this article. The most representative methodological foundations in the context of our micro-research are general semiotic concepts for the analysis of cultural text, its logical-symbolic and semantic structure (R. Barth, Y. Lotman); a special role in understanding the text of the play and its semantic depth is played by the hermeneutic tradition (M. Heidegger) and post-structuralism (J. Kristeva). Lotman); a special role in understanding the text of the play and its semantic depth is played by the hermeneutic tradition (M. Heidegger) and post-structuralism (J. Kristeva). Lotman); a special role in understanding the text of the play and its semantic depth is played by the hermeneutic tradition (M. Heidegger) and post-structuralism (J. Kristeva).

The musical comedy “Stepmother Samanishvili” by V. Konstantinov and B. Ratzler based on the story by David Kldiashvili (1896; premiered in December 2019, direction and set design by Sergei Fedotov) immerses the viewer in the atmosphere of ancient Georgia already in the theater foyer, decorated with visual images of Niko Pirosmiani and permeated with the musical sounds of national melodies. And the author of the play, director Sergei Fedotov, preceding the performance, will come out to the audience with his traditional greeting in a sheepskin hat typical of Caucasians, imitating a funny Georgian accent like an actor. The image of fabulous, patriarchal-hospitable, generous, burning Georgia is recreated on stage using all the arts. This is the word, and drinking songs, and fiery Caucasian dances, expressive acting and plastic arts, and scenography, and light. This is a temperamental manner and characteristic accent of Georgian speech, gestures. According to the genre, the story told by the theater from the stage can at first be perceived as a cheerful anecdote, of which many go from one village to another, from one village to another, from one nation to another. An old widower has decided to marry a second time, and his son and daughter-in-law are afraid that their child will have a competitor for his grandfather’s inheritance. The problem is serious, as the family barely makes ends meet. The last sack of flour remains, and the only cow is not calving or giving milk. This is where the intrigue begins: the

son and his wife decide to find a barren bride for their father. The neighbor also joins the conspiracy. The viewer laughs with pleasure when potential brides dance coquettishly one after another in front of the puzzled father, the newly minted groom - hunchbacked, toothless, lame, one-eyed widows, wooed by an enterprising neighbor. These comic shows in the play are performed in the tradition of Georgian amusing spectacles, which is called "tamasha". The adventurous plot unfolds on stage with masterly fun and masterly speed. A gambling trade between a brother-in-law and a widower's son leads to an agreement. The brother-in-law decides to make a profitable exchange: for the elderly stepmother - the future bride, who still needs to be stolen from the neighboring village, to take a calving cow as payment for help in matchmaking.

However, director S. Fedotov would cease to be himself if he limited his artistic message to the viewer to only simple buffoonery and buffoonery. Convincingly recreating in all details pictures of the life of a Georgian village at the beginning of the 20th century, morals, customs, authentic air of time and place, the theater set itself a difficult task - to show not only the features of the Georgian national character, its passion, beauty, inner strength, but also to talk to viewer about serious things. The characters of the play in the plot go through joy, revealing to the viewer their innocence, sincerity, naivety, loyalty to the ancient customs of their ancestors, but also through moral trials and suffering. Georgia on stage is a land not only of colorful characters, but also of individual choice between good and evil. The theater creates a stage model of the existence of heroes, an alternative to the spiritual decay of the modern world. The performance presents with impressive infectiousness the contrast between the correct life and the false life; the choice of honest and humane, and the choice of evil. After all, the anecdotal plot of Georgian history could have developed differently, and would have ended in a terrible crime, infanticide, if the old father's son and his wife had carried out their insidious plan to the end, consistently and in cold blood. And what kind of miracle happened? The fact of the matter is that genre transformation transforms the entire structure of a theatrical performance from an anecdote not even into a good Christmas tale, but into a parable. Through the signs of the profane, empirical world, with all its exotic details, in the artistic space of the performance an image appears not of the past, a hundred years ago, and not even of the Caucasus as an ancient land; not the mythological East, but Eternity. A house under plane trees and cypresses, a courtyard under the scorching sun of Georgia, a southern garden, flowers, a village cemetery, mountains, and a river, throaty speech, Caucasian feasts, lezginka, grape wine, lobio, matsoni, and satsivi. All of this, revealed to us, residents of the northern latitudes, the Western Urals, is an image of eternity. God is present here, and it is from God's position that each hero is seen through and through, with his thoughts and feelings, delusions and weaknesses. And the viewer becomes a wit-

ness to the inner life of the characters. The Perm Theater near the Bridge has found Georgian material in which reflections on the spiritual destiny of a person do not depend on the conjuncture of time. There is a remarkable coincidence of the meaning of the Georgian ethical parable and the internal intention of the Perm Theater “At the Bridge”: to talk about today’s man - in a situation of total self-interest, double-mindedness of time, pragmatism. A great craving for harmony and faith in man is expressed in the development of the characters of the characters told in the play, a parable about temptation and transformation of the human soul - from self-interest to sacrificial love and brotherly feelings. The happy end of the family story in the play is connected not with a miraculous sign from above, but with a chain of natural coincidences, providential, because they awaken in the characters an intuitive memory of their origin “in the image and likeness of God.” The theater is following the path of sudden destruction of audience expectations and common stereotypes of perception of human nature. It turns out that a person is not what he seems at first glance. The moral effort of conscience makes him unequal to himself. And his soul can develop while he is alive and is able to feel shame, pain, and involvement with other people. From the point of view of Christian anthropology, a person can fall and rise, destroy his soul by sin and be spiritually reborn. But this is the plot of the play that is obvious to the viewer. However, there is also a deep plot in which the heroes are not equal to a given scheme, stereotypical ideas about them. The elderly stepmother suddenly turns into a caring mother and a wise wife. A barren widow gives birth to two babies one after another. A calving cow also becomes a potential mother. But the most important metamorphosis occurs with the soul of the main instigator of the intrigue against his father - a poor son, in whose heart brotherly love for his newborn younger brother replaces deceit and cruel calculation. In his directorial statement, S. Fedotov is the creator of a complete meaning, a complete moral formula. He makes the biblical norm of humanity vividly clear: “Love is long-suffering, merciful, love does not envy, love is not arrogant, is not proud, does not act outrageously, does not seek its own, is not irritated, does not think evil, does not rejoice in unrighteousness, but rejoices with the truth; covers everything, believes everything, hopes everything, endures everything...” [5, 13: 4-8, 214]. It does not act outrageously, does not seek his own, is not irritated, does not think evil, does not rejoice in untruth, but rejoices with the truth; covers everything, believes everything, hopes everything, endures everything...” [5, 13: 4-8, 214]. does not act outrageously, does not seek his own, is not irritated, does not think evil, does not rejoice in untruth, but rejoices with the truth; covers everything, believes everything, hopes everything, endures everything...” [5, 13: 4-8, 214].

The theatrical staging “One Flew Over the Cuckoo’s Nest” (direction and set design by S.P. Fedotov, December 2022) is based on the cult novel by American

writer Ken Kesey "One Flew Over the Cuckoo's Nest" (1962). Perm director S. Fedotov offers his version of the story of patients in a psychiatric clinic and rightly emphasizes that in working on the play the theater followed the plan of the author of the novel, and not the script of the famous film by M. Foreman (1975) with Jack Nicholson in the title role. And in fact, the artistic frame of the action on stage becomes the Leader's intermittent internal monologue, weaving, in a stream of traumatized consciousness, the myth of the archetypal hero, based on his own, semi-conscious, memories, impressions and assessments of real tragic events. In the play, as always with S. Fedotov, one is attracted by the thorough and detailed accuracy of the actor's portrayal of the characters' roles; the authenticity and density of the atmosphere, saturated with anxious tension and expectation (reaching its dramatic climax in the tragic scene of young Billy's suicide and McMurphy's despair at the moment of reprisal against his sister Ratched); the finest nuances of images; the contrast of the tempo of the action, catastrophically and steadily drawing the viewer towards a cathartic release of the tragic plot; ensemble as the main principle of constructing a performance; a masterful technique of acting transformation that reveals the archetypes of human characters, provided that fantasy, improvisation and concentration are included (the brilliant acting of the actors should be noted). The stage version of Ken Kesey's social-psychological drama tackles challenging issues that are particularly relevant for individuals today. It explores the possibilities and limitations of freedom in modern civilization, the tragic conflict between individuality and disciplinary systems, and the violence and suppression of human will. It delves into existential anxieties and fears that drive individuals to "escape from freedom." [6, 18]. The story that unfolds before the eyes of the viewer on the stage of the Perm Theater "U Mosta" is frightening from the very beginning, alarming with its ambiguity. The story is told on behalf of one of the hospital patients, an Indian nicknamed "Leader" (D. Ivanov). And it seems that his view of what is happening cannot be adequate. After all, he clearly shows signs of a mental disorder. The hospital seems to him like a mechanical factory churning out human robots. The mechanisms work clearly and harmoniously. If a defect occurs, then several damaged copies are sent for processing to another floor of the clinic. And at the same time, what is happening on stage, even from the point of view of common consciousness, increasingly resembles a nightmarish hallucination. On the stage, in a completely white color scheme, a picture is constructed representing a section of a modern, technologically advanced hospital. There is a relentless, soul-wrenching music that cannot be turned off. There is a monotonous daily routine that robs people of their sense of time. There is a forced shower against the patient's will. There is a taking medication with the necessity of demonstrating an empty mouth to the medical staff. There is a widespread strict control and surveillance over every movement of the patients. Sys-

tematic group psychotherapy sessions, resembling more of public auto-da-fé of the Middle Ages, with sadistic tortures of the victim driven to hysteria. The viewer gradually realizes that these are not just horrifying scenes from jokes about psychos. The clinic is a model of modern social order. A metaphor for a system that strictly regulates every step, every movement, expression of will, desire of any of us. A person who leads a plant-based existence (food-work-sleep) is not dangerous under any regime and completely suits everyone. The rules are aimed at the complete subjugation of a person. Is this a new order? It is unlikely. The context of history and culture will not allow us to make mistakes if we remember all the conceivable and inconceivable utopias and dystopias in the history of mankind from Plato to Campanella, from Proudhon to Marx. From Dostoevsky (“The Dream of a Funny Man,” “Demons”), to E. Zamyatin (“We”), F. Kafka (“In the Penal Colony”), V. Nabokov (“Invitation to an Execution”), J. Orwell (“1984”) In the play, like Ken Kesey’s, the head nurse, Miss Ratched (A. Perova), turns out to be the personification and personification of the authoritarian system that suppresses all manifestations of human dignity, free will, and the right to independent choice. But she is not completely normal; she has her own complexes and phobias. A person with a power complex is a monster. In the sleepy, faceless nest of the cuckoo (the cuckoo throws its chicks into other people’s nests? Is it crazy - is it Ku-Ku?), among the “chronicles”, “spicy” and “vegetables”, imaginary peace and order suddenly gives way to Dionysian chaos when they bring to the hospital department of a new patient - the red-haired Irishman McMurphy (I. Baboshin). A hooligan, by the nature of his nature, is in no way a revolutionary, but rather a trickster, an anti-hero, an antisocial type, who hoped to “get out” of hard labor in a mental hospital, turns out to be the charismatic leader who makes the rest of the clinic’s patients again feel a taste for living life, wake up from your mental infantilism, to feel the joy of being. It is he, the vital biophilous person, and not the sadist Ratched, who manages, with his independent behavior, disregard for the senseless hospital rules that dupe people, to show them that they are people, to remember their human dignity. The viewer is exposed to the tragic stories of each of the patients in the department. Thrown out of society for one reason or another, not fitting into its strict framework and requirements, they gave up and gave in to the iron laws of the modern world. And together with McMurphy, the viewer is surprised to learn from their frank confessions that they are not at all forced, but are here voluntarily. Therefore, freedom is not such a light burden. External freedom is only a consequence of gaining internal freedom. And inner freedom is, first of all, the ability to make independent choice and act independently. And this is the most difficult thing. It is much easier to entrust the decision of your destiny to someone else, who is strong and big. “The world belongs to the strong” [7, 45]. “You’re big, and I’m still small...” [8, 48] the Leader says to his new friend Mc-



Murphy, although he is two heads shorter than him... Thus, the patients of the clinic are not only victims of the system, but they themselves support it... However, McMurphy was not used to giving in to difficulties. “To be saved, you just need to start acting” [9, 67]. He excites their imagination, makes them think, do things, appeals to their conscience, wins tangible victories not only over the system of the despotic hospital regime, but above all over their psychological complexes. In a carnival of events, the action unfolds rapidly, from his first defeats (a failed attempt to move a marble washbasin in the bathroom to break the bars on a hospital window - when, to the laughter of the other patients, a discouraged McMurphy stubbornly retorts: “But at least I tried” [10, 67], - and the viewer, witnessing this failure of the hero, becomes clear that man - “this is the effort to become a man” [11, 22] until victories (the re-voting scene; the unexpected cure of the “deaf-mute” Leader; the improvised collective ecstasy of the fans baseball games in front of a switched-off TV; a crazy drunken party, culminating in the “initiation” of the young man Billy from a boy into a man). The confrontation between the rebel McMurphy and the iron Miss Ratched will end tragically for the hero. However, his charges, friends from the psychiatric hospital, students, learned his lessons of human solidarity, freed from fears, found their own voice... And his most faithful student, the Leader, who, thanks to McMurphy, found himself, breaks the window and runs to freedom. However, he will not leave the broken McMurphy here, just as McMurphy himself did not leave his unfortunate comrades to be torn to pieces by the vulture, the head nurse. The leader strangles the lobotomized McMurphy, symbolically taking him with him to freedom. After all, it is only an empty shell of a friend that remains within the walls of the hospital. The heroic soul of McMurphy has already become an immortal legend. And to be free, you need to have great courage. “You need to endure pain; sacrifice one; confront nothingness, death, fate, emptiness and lack of meaning, guilt and condemnation. This is the “courage to be” [12, 200]. The performance ends, the viewer is left with the feeling of presence and participation in the miracle of confrontation, struggle, death, salvation and rebirth of man that has just happened before their eyes.

Thus, modern theater demonstrates its competitiveness in the study of man, his nature and his freedom, along with philosophical anthropology, and sometimes in confrontation with it, in the forms of artistic and figurative comprehension, cognition, comprehension and stage interpretation of human behavior.

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现阶段俄中关系的和解与互动  
**RAPPROCHEMENT AND INTERACTION BETWEEN RUSSIA AND  
CHINA AT THE CURRENT STAGE**

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抽象的。研究总结了现阶段俄罗斯与中国和解的原因。美国将俄罗斯和中国视为最大的竞争对手和安全威胁，频繁在全球战略和法律层面施压，阻止俄罗斯和中国的发展。在此背景下，俄中两国都认识到，必须加强合作，增强自身实力，才能应对西方的偏见和敌意，维护自身及周边地区的安全稳定。与传统的结盟手段不同，新型国际关系主张构建更加和平的国家关系，避免因俄中合作而导致地区紧张局势迅速升级的问题。

关键词：俄中合作、安全、稳定。

**Abstract.** *The research summarizes the reasons of rapprochement Russia and China at the current stage. The United States regarded Russia and China as the biggest competitors and security threats, and put frequent pressure on the global strategy and legal level to prevent the development of Russia and China. In this context, both Russia and China have realized that they must strengthen cooperation and enhance their own strength in order to cope with the prejudice and hostility of the West and maintain the security and stability of themselves and their neighboring regions. Different from the traditional means of alliance, the new type of international relations advocates the construction of more peaceful state-to-state relations, avoiding the problem of rapidly rising regional tensions caused by Russian-Chinese cooperation.*

**Keywords:** *Russian-Chinese cooperation, security, stability.*

The Soviet Union, once America's greatest rival, ceased to exist after its collapse, giving the United States the status of the world's sole superpower. As a superpower, the comprehensive strength of the United States far exceeds that of other powers in the world. The United States, which has gained a dominant position in the world, maintains a unipolar world centered on its own country. While

using its powerful projection capability to project its influence around the world, the US also actively promotes its own values, seeks to make all countries in the world accept its neoliberal ideology, assimilates other countries ideologically, and exports color revolutions, so as to obtain more Allies and support.

The dominance of the United States has come into conflict with the development of countries which are not considered allies of the United States, which has led to the emergence of emerging countries to challenge the dominance of the United States. Among them, China and Russia have the strongest comprehensive national strength, and at the same time, China and Russia do not fully accept the world order and values arranged by the United States. With the deepening of globalization, the development of China and Russia has gone beyond geographical factors, seriously interfering with the global layout of the United States, and challenging the position of the United States as a world leader. Therefore, while maintaining the containment policy against Russia, which inherited the legacy of the Soviet Union, the United States also listed China as a competitor and imaginary enemy, and began to implement multiple containment policy against China and Russia.

The main measures the US has taken to contain China are as follows: interfering in and hyping up China's internal affairs in Xinjiang, Tibet, Hong Kong and Taiwan, imposing sanctions on relevant Chinese companies and personnel under the pretext of human rights issues; Co-optation with China's neighboring countries, hyping up and provoking China on its territorial issues, such as the Diaoyu Islands incident and the South China Sea issue; Crackdowns on China's export trade, with export controls, a squeeze on overseas markets and investment screenings; Blocking China's high-tech industries, such as artificial intelligence, communications technology, biotechnology and semiconductors, of which semiconductors have been a hot topic this year. The United States used its allies to organize the «deterrence alliance» to restrict the development of China's semiconductor technology, restrict China's import of lithography machines, and prohibit China from using EDA modules, an essential tool for chip design.

To Russia, the United States mainly restricts its external capabilities by expelling Russian diplomats on the grounds of interfering in the internal affairs of the United States and engaging in espionage activities. Cracking down on the Russian energy industry, such as banning the sale of advanced equipment to Russia and banning investment in the Russian energy industry; Ignoring the promises made before the collapse of the Soviet Union, hyped up the Russian threat, repeatedly expanded NATO to the east, suppressed Russia's living space, and limited its influence and discourse power in Eastern Europe. In February 2022, after the Ukraine crisis broke out, the United States and its allies announced further sanctions: sanctions on Russian entities, individuals, senior officials, freezing as-

sets and restricting transactions; Financially, the United States restricts Russia's issuance of Treasury bonds in the capital market, and restricts Russian private and government loans, investments, insurance and underwriting. The Association for Global Banking and Financial Telecommunications removed some Russian banks, restricting their access to cross-border dollar transactions. Restrictions on exports of semiconductors, computers and sensors to Russia.

The U.S. policy of containment against China and Russia has slowed their economic growth, limited their influence and voice on the international stage, and negatively affected their technological development. At the same time, the containment policy adopted by the United States against China and Russia has also worsened the China-US relations and Russia-US relations, damaging the relations between China and Russia and other Western countries, while the Sino-Russian strategic partnership of coordination has been strengthened and the political color of the bloc has become prominent. In the economic and trade sphere, the decoupling of China and Russia from the US has already begun: the US has pushed to shift supply chains towards allied countries; Russia actively promotes «de-dollarization»; China has increased investment in independent scientific and technological research and development.

China and Russia have already learned lessons from history and decided on a peaceful way to live together. The containment policy of the United States pushes the two countries closer to each other to seek cooperation and common development, so as to balance the power of the United States, prevent the threat of the United States and its Allies to the sovereignty of the two countries, and clear the obstacles in the path of development.

Under the background of the dual containment of the United States against China and Russia, based on the common interests and development demands, the two countries changed the relatively cold state at the initial stage of the disintegration of the Soviet Union, established a high degree of political mutual trust, actively cooperated and interacted, and combined forces to get rid of the development obstacles and external threats built by the United States and its Allies for the two countries. Today, China and Russia see each other as their biggest opportunity for development, and each as their top diplomatic priority. In the context of Western containment and fraud, the two sides actively promoted strategic mutual trust to guarantee their own security and stability on the home front in the face of external threats. In the trilateral relationship between the United States, China and Russia, China and Russia have also realized that they must unite in order to have the confidence and strength to say «no» in front of the West.

Chinese president Xi Jinping has repeatedly proposed that China and Russia should increase mutual support, promote synergy between their development strategies and the construction of the Belt and Road Initiative and the Eurasian

Economic Union, and strengthen coordination and cooperation in major international and regional affairs. The two countries should support each other on issues concerning each other's core interests and major concerns, and continuously consolidate and deepen political and strategic mutual trust.

In the economic field, on the basis of a large number of economic cooperation in various fields since China and Russia reached the strategic cooperative partnership, the interaction between China and Russia in response to the containment of Western forces has become more frequent and close in recent years, with rapid development.

Transport and logistics between China and Russia have grown rapidly in recent years. Faced with the disruption of Russia's foreign trade in 2022 due to the conflict in Ukraine, Russia and China have forged closer ties in the transportation sector. Through Manzhouli and Suifenhe in China, the ports into Russia have become the main road of China-Europe freight trains. The first railway bridge connecting China and Russia, Tongjiang Bridge, was opened in November 2022, with a current maximum annual capacity of 5.2 million tons, which can be increased to 20 million tons in the future, becoming a new corridor for railway transport between China and Russia in the east. In addition, China and Russia plan to build a new logistics and transportation center near the trans-Amural railway bridge, which is expected to be able to transfer 15 million tons of cargo per year. On June 10, 2022, the China-Russia Heihe-Blagoveshchensk road Bridge was officially opened, allowing goods shipped from China's Heilongjiang province to be directly transshipped to Moscow without passing through a third country. Major cities in China, such as Harbin, Zhengzhou, Qingdao and Beijing, have opened direct cargo plane routes to Russian cities. In addition, China's ports of Quanzhou, Qingdao and Nansha have also opened sea routes to ports in the Russian Far East.

Russia, which has suffered the fiercest economic sanctions from the West during the military conflict with Ukraine, was removed from the SWIFT [Society for Worldwide Interbank Financial Telecommunication] system. Under such circumstances, China and Russia actively promote local currency settlement. By December 2022, the proportion of local currency settlement in China-Russia trade has reached 50 %. Since 2016, the Central Bank of Russia has included RMB as its foreign exchange reserve, and by 2020, RMB has become the third largest foreign exchange reserve currency of the Central Bank of Russia.

Moreover, under the framework of the SCO, China and Russia have actively played the role of leaders of the organization and promoted multilateral cooperation. Even though the sanctions and containment caused by the Russia-Ukraine conflict pose challenges to the activities of the SCO, the regional cooperation based on the SCO is still proceeding with a good momentum. The SCO has unlocked potential advantages in the energy and transport sectors; Increased the number of

member states, further expanding the market space and scale; Strengthening strategic coordination in Eurasian regional cooperation; It advocates the mechanism concept and model of openness, mutual benefit, inclusiveness and sharing, and further releases the mechanism effectiveness of regional economic cooperation in highlighting the concept of openness and strengthening institutional identity . Guided by the Shanghai spirit, the SCO is showing the rest of the world what is possible beyond the zero-sum game.

In the political field, China and Russia have conducted interactions based on respect and cooperation, maintained stability in Central Asia, their common neighborhood, and prevented the «color revolution» from affecting the neighborhood. For China's «Belt and Road» Initiative and Russia's «Eurasian Economic Union» strategy, the two sides have developed a inclusive model to avoid strategic contradictions between the two countries.

The interaction between China and Russia is based on the principles of mutual respect, equality and win-win. It is not an act of alliance, nor is it conducted by either side under the direction or coercion of the other. This mature major-country relationship provides a strong support for China and Russia to deal with external challenges, while ensuring that their cooperation will not cause international tensions and lead to more sanctions and containment.

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使用新型杀菌剂增强书籍免受生物损害的保护  
**ENHANCEMENT BOOKS PROTECTION FROM BIO-DAMAGE  
WITH NEW FUNGICIDES**

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注解。由于洪水、灭火、供水系统故障和其他与水有关的事件，书籍会受到物理损坏并发霉变质。要去除书籍中的真菌，您只能使用不会对图书馆资料产生负面影响的杀菌剂。在整个保护历史中，实践中使用的物质都没有满足所有严格的要求，这就是为什么对新制剂的探索一直持续至今。介绍了多年使用杀菌剂处理书籍的经验，并提出了对皮革、纸张和羊皮纸几乎无害的新制剂。俄罗斯国家图书馆测试了 50 多种化合物，以保护图书馆藏书免受生物损害。四种杀菌剂单独或协同混合用于处理书籍。选择每种杀菌剂对每种微生物的有效浓度。

关键词：生物降解、霉菌、杀菌剂、图书馆、书籍。

**Annotation.** *As a result of floods, fire extinguishing, water supply system breakdowns, and other water-related incidents, books are damaged physically and deteriorated by mold. To remove fungi from books, you can use only those fungicides that do not negatively affect library materials. None of the substances used in practice ever met all the exacting requirements during the whole history of conservation, that's why the search for new preparations went on and is going up to now. Many years of experience in the use of fungicides for processing books is presented and new preparations are proposed that are practically harmless to leather, paper, and parchment. More than 50 chemical compounds were tested at the National Library of Russia for the protection of library stocks from biodamage.*

*Four fungicides individually or by synergic mixture are used for treatment of books. The effective concentrations of each fungicide for each type of micromycete were selected.*

**Keywords:** *biodeterioration, mold, fungicide, library, books.*

The defeat of documents by micromycetes has been observed everywhere and that is a global problem. Especially dangerous are emergencies and natural disasters that are caused by water.

There are many examples of such disasters. When floodwaters infiltrated the Biblioteca Nazionale Centrale in Florence, Italy, in 1966, it damaged more than two million volumes of materials and manuscripts, including 100,000 rare volumes from the Magliabecchi collection, newspaper collections, 50,000 folios of the Palatina, and the card catalog.

The same flood submerged more than 200,000 volumes of books at the University of Florence. In 1975, floodwaters infiltrated the Case Western Reserve University Library in Cleveland, Ohio, affecting about 50,000 maps and 40,000 books. Floods are not the sole cause of water damage in libraries [1].

In 1986, the library of the Chicago Historical Society suffered due to a water supply system breakthrough and because of a fire — the Los Angeles Public Library. [2]

The 1988 fire in the Russian Academy of Sciences caused About 734,465 copies volumes to become damp due to firefighting foam. The damp books were initially frozen however, about 10,000 books became moldy [3].

Hurricane ‘Hugo’ in 1989 damaged the Montserrat Public Library. The library was under approximately four inches of water. Materials from the newspaper and paperback racks and from the magazine display had ended up in the water gathering on the ground. The library lost some 6,000 books [4].

As a result of the breakthrough of the hot water supply system, when 6 tons of water were spilled, 200 thousand storage units were affected in the Vernadsky National Library of Ukraine in 2002 [5].

The 2004 tsunami in South and Southeast Asia nearly destroyed several libraries permanently, hurricane Katrina in 2005 destroyed 23 public libraries and damaged 70 in Louisiana alone. [1]

Yongquan Monastery in China which had a rare collection of ancient books was damaged due to typhoon Longwang in October 2005 the documents were already infected with mold and the typhoon made the situation worse. More than 5,000 volumes of Buddhist classics were immersed in the water. The paper of the documents was fragile and was damaged by the muddy water, and the characters had faded. The extreme drought conditions in the region led to a water main break that inundated the campus art and architecture library [6]. Over 17,000 volumes

were vacuum-freeze-dried. Heavy rains in 2006 flooded the basement of New York's Sidney Memorial Public Library [7].

A broken heating pipe in the Library of the Culture Palace for Nationalities of China caused hot water damage to nearly 21,000 materials, including ancient books [1].

In August 2009 the Louisville Free Public Library in Louisville, Kentucky, experienced a flash flood that caused damage to the library, leaving behind damaged computers, vehicles, furniture 50,000 damaged books [8].

The earthquake that occurred in 2011 in Japan was one of the reasons why books were damaged by water and mold. According to Iwate Prefectural Library statistics, five libraries in the prefecture were destroyed by the tsunami. The approximate number of damaged materials belonging to those libraries would have been more than 206,000. This is approximately 4.2% of the total amount of materials posted throughout the prefecture. But it may happen to any librarian that he will have to work with a small amount of wet or partially moistened materials, mold infection may occur if an air conditioner breaks down, a pipe leaks, or other water damage. The workshop describes the removal of mold. The participants got acquainted with the procedures for treating contaminated materials [9].

Hurricane 'Gilbert' hit the Jamaica Library Service system and many of its branches were also damaged. Overall loss of over 150,000 books and periodicals was reported due to it [6].

Books that fall into the water lose their appearance, the bindings are destroyed, and water traces on paper are formed. Another serious problem that may arise if books are not dried or frozen in time is the growth of mold fungi that pose a danger both to library materials and staff in archives and libraries [10].

To stop the growth of micromycetes, it is necessary to use special preparations — fungicides. According to the National Program on the preservation of library stocks of Russia since 2001, we have visited 92 libraries in 53 cities in Russia. The main goal was to inspect the documents and document storage conditions (including the buildings). As a result, it was revealed that books damaged by fungi were absent in three libraries only.

Thus, the problem of the biodamage of paper documents remains extremely relevant. One of the ways to struggle with biological damage is the use of fungicides.

Studies have shown that by removing mold from books made of different types of paper, as well as leather, parchment, and other materials, an individual approach is required. In addition, the degree of damage by microscopic fungi should be taken into account. One of the most practical and economical ways to disinfect documents affected by mold fungi is manual sheet processing, when an individual approach to the document is carried out, depending on the degree of its bio-dam-

age and the type of library material. Fungicides kill viable spores and mycelium, consequently preventing damage to the document and ensuring the safety of people working with documents affected by mold. The death of microorganisms under the action of a fungicide occurs as a rule in a liquid medium (in an aqueous or alcoholic solution).

Fungicides have been used in the libraries of Russia for a long time. A special search of biocides for the culture field was not carried out, commonly they used medical preparations, pesticides, algicides, and preparations against the deterioration of varnishes and paints by fungi. Many chemicals that were introduced in the conservation practice included phenol derivatives, aldehydes, anilides, imines, organometallic compounds, and others.

The use of each compound depends on the destination and application nature of the preparation in the cycles of conservation. Some fungicides are suitable only for the definite restoration process, others are more universal, and the third ones are suitable for the accessory materials. The question of the protection of objects that suffered in periods of large emergencies or disasters is of special acuity when in order to save values being in the state of mass affection, one has to use fungicide which does not meet all the necessary requirements.

Investigation and practical use of each preparation was carried out not at the same one, but at the various conservation divisions of the cities of Moscow, Petersburg, Nizhniy Novgorod, and Kazan. Duration and terms of use of one or another preparation were different.

Fungicide, which is efficient against fungi, is always a chemically active compound, and so it can negatively influence both a human and library material. They have definite physicochemical properties that might negatively impact the basic properties of library materials: strength, whiteness, and acidity. For example, quaternary ammonium compounds cannot be used for documents as they decrease the mechanical strength of paper.

Biocides recommended for the library materials should meet the following requirements [11]:

- Ability to kill all the microorganisms in any stage of development,
- Harmlessness for book material at the long-term storage and exposition,
- Harmlessness for people,
- Low hygroscopicity,
- Absence of color and smell,
- Nonvolatility,
- Time stability,
- Reasonable cost,
- Ease of use.

None of the substances used in practice ever met all the exacting requirements during the whole history of conservation, and so the search for new preparations went on and is going up to now.

The following chemical compounds were used in the conservation of paper documents during more or less noticeable time: formaldehyde, 6-isopropyl-1,3-cresol (thymol), 2-hydroxynaphthalene ( $\beta$ -naphthol), dihydroxydiphenylmethane, pentachlorophenol, and other phenols, anilide of *o*-hydroxybenzoic acid (salicylanilide), 8-hydroxyquinoline, methyl *p*-hydroxybenzoate (Nipagin), tributyltin-methacrylate copolymers, quaternary ammonium compounds, and their mixtures, trichlorobenzoxazolyne (Trilane).

The very first preparation used to protect books was formaldehyde, but it had only fungistatic properties, then it was thymol; sometimes they are still used today: formaldehyde is introduced in glue, and thymol is used for the disinfecting treatment of leather bindings. Thymol was used for book treatment per sheet and was added into lubricant for the stabilization of leather bindings.

Every five to ten years, new substances were introduced into conservation practice, and each new proposal had its positive features, but also negative ones:  $\beta$ -naphthol, ethyl-mercuphosphate, and rhodanacetanilide were recognized as the best ones. Then  $\beta$ -naphthol was replaced by sodium pentachlorophenolate. It was also used for glue protection. Salicylanilide, sodium pentachlorophenolate, and 8-hydroxyquinoline were used in practice. Each of these compounds did not satisfy restorers, so the search for new preparations went on and sodium pentachlorophenolate was replaced by methyl *p*-hydroxybenzoate (Nipagin). At the following stages, trilane (4,5,6-trichlorobenzoxazolynone) was actively used, captain (trichloromethyl mercapto-4-cyclohexene-1,2-dicarboxyimide) was used in restoration work in Ukraine.

In the 1970s–80s, 39 chemical compounds were investigated at the National Library of Russia (NLR). Eight of them were considered as more or less proper ones and one was recommended for application in restoration practice: polyhexamethylene guanidine in combination with polyethyleneimine. Their properties at long-time storage were taken into account. Decay products of polyhexamethylene guanidine  $[(\text{NH}_2)_2\text{CO}]_n + \text{NH}_4\text{Cl}$  enable us to increase the alkaline reserve of paper. Safety on its decomposition is a positive property of the preparation. Polyhexamethyleneguanidine hydrochloride (PHMG) is water-dilutable and has low toxicity; it attaches biostability to paper and fabrics on introduction in binding agents and impregnation and increases mechanical strength and durability [12].

In 1988, mass fumigation of more than 8,100,000 books and newspaper files, which suffered during the extinguishing of fire with water, was carried out in the space of 44,000 m<sup>2</sup> in the Library of the Russian Academy of Sciences. The storage was sealed hermetically, air was heated, then moistened, and then fumigation

with formaldehyde was carried out for 1–4 days. Then formaldehyde was removed by means of filters with active carbon and silica gel treated with ammonia. formaldehyde can be sufficiently easily converted into the state safety for a human:  $6\text{CH}_2\text{O} + \text{NH}_3 = \text{C}_6\text{H}_{12}\text{N}_4 + \text{H}_2\text{O}$ . This method does not have any analogs in world practice; it obtained a favorable evaluation from the UNESCO Commission.

There were 48 types of fungi removed using fungicides of the Janssen Pharmaceutical NV on the statues of soldiers of the world-famous terracotta army of Emperor Qin Shi Huang (Xi'an, Shanxi Province), which were damage by mold [13].

At the NLR and at the Library of the Russian Academy of Science high-frequency disinfection is used. Dielectric heating in a working condenser with a field intensity of 165 kV/m and frequency of 3.5 MHz to a temperature of 70-95°C is reached during 2-10 min depending on the composition and humidity of books.

More than 50 chemical compounds of the following groups were tested before the 1990s only at the NLR for the protection of library stocks from biodamage: halogenated hydrocarbons of aliphatic series, quaternary ammonium bases, polymeric compounds of cationic type, phenols, aldehydes, alicyclic carboxylic acids, derivatives of aromatic carboxylic acids, derivatives of dithiocarbamic acid, azo and diazo compounds, organomercuric compounds, organotin compounds, heterocyclic compounds [11]. However, the use of some preparations has become a historical fact.

But before we recommend each new compound for the document conservation, we should test it according to all the abovementioned requirements. It is connected with that manufacturers are not accurate in pointing out their formula and any additive can result in a decrease of the main mechanical and physicochemical properties of paper. All the chemical compounds used at the NLR were tested for the artificial aging of paper in the case in which the preparation was used. Ageing was carried out. Paper whiteness, breaking strength, and tensile strength were determined immediately after treatment with biocide and artificial aging. Whiteness was determined with Specol (Carl Zeiss), and Elrepho (Lorentzen & Wetzte). Tensile strength formerly was determined with experimental setup RMB (Ukraine), and now it is determined with Hounsfields TEST H25K-S (Equipment LTD). A number of double folds formerly was determined with experimental setup I2-1 (Russia), and now it is determined with Tinius Olsen M.I.T. Folding endurance tester (Testing Machine Co Willow Grove PA).

As a result of the tests that were made by early 2000, two biocides were recommended: polyhexamethylene guanidine hydrochloride (or phosphate), which already in the 1970s attracted the attention of restorers, and Metatin GT (Rocima GT), which contain aliphatic and heterocyclic compounds. 1,485,306 documents of NLR were disinfected against fungi by treatment with Metatin GT. And about 500,000 were disinfected at other libraries in Russia.

From 2001 to the present more than 40 biocides and 20 essential oils proposed by various firms were investigated at the NLR. Mainly those preparations contain the derivatives of polyethyleneimine, particularly polyhexamethylene guanidine and the derivatives of isothiazolinone.

The outcome of the complex tests the fungicides Sanatex, Rocima 243, Rocima GT, and Anti-B were selected as the most effective against the mold. All of them contained isothiazolinone derivatives as the major active agent. Individual resistance to these fungicides was determined for micromycetes having a wide range of tolerance regardless of their habitat conditions and being indicators of contamination in the indoor repositories' air in libraries and on the documents' surface (*Alternaria alternata*, *Aspergillus niger*, *Cladosporium cladosporioides*, *Penicillium aurantiogriseum*, *Penicillium commune*), for *Trichoderma viride* having high cellulase enzymatic activity, for *Mucor plumbeus*, that often has found on the surface of documents with high dustiness, and for *P. funiculosum* and *P. purpurogenum*, which often cause pigmentation of the paper. The effective concentrations of each fungicide for each type of micromycete were selected. Experiments on the selection of fungicides were carried out with the most active strains capable of destroying library materials: wood, leather, paper, glue, etc., which means having cellulase, amylase, and proteolytic activity.

Currently, for the treatment of paper affected by mold fungi, 0.5% and 1.0% aqueous solutions of Sanatex are recommended, depending on the degree of damage to books. In addition, the synergistic mixture of 1% Rocima 243 and 2% Phosphopag (polyhexamethylene guanidine chloride) in a ratio of 2:1 is used.

In emergencies, if books are damaged by water, the bindings are the first to be affected by mold. In addition, the leather is a porous material where microbial cells are retained, so other options are offered for the treatment of leather bindings: from 1 to 5% Rocima aqueous solution, depending on the degree of fouling of the binding, or a 10% aqueous solution of the Sanatex.

Parchment is quite a delicate material; therefore, a specific approach is needed. For processing parchment manuscripts and bindings mixtures of water-alcohol solution 1% fungicide Rocima GT: ethyl alcohol: water in a ratio of 1:800:200 or a 2% solution of Rocima GT: ethyl alcohol: water in a ratio of 2:800:200 are used.

In conclusion, there are some words about the prospects of the use of fungicides in our country. Lately, fungicides began to be refused in some restoration cycles because of the introduction of synthetic polymeric materials. However, some of them are used by some restorers for instance for the conservation of glue. All fungicides introduced into objects during their restoration remain in the composition of the material. In various circumstances, they come into contact with humans. So, to use more secure substances, the search for new fungicides is going on. These fungicides have to be applied at the lowest possible concentrations, have minimal effect on library materials and would be absolutely safe for library staff.

But the main thing is that libraries should be protected from water entering into them, and in case of an accident, books should be dried to prevent the mold development on them.

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纤维素破坏微生物的一些特征  
SOME CHARACTERISTICS OF CELLULOSE DESTRUCTOR  
MICROMYCETES

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注解。 图书馆储藏室空气中和书籍表面的真菌对文件纸张、装订皮革以及管理员和图书管理员构成危险。 真菌的某些特性决定了它们对不利环境条件的抵抗力, 因此能够在图书馆中生存并对书籍造成生物损害。 介绍了图书馆、档案馆藏品中出现频率较高的微生物的培养基酸度、温度、光照和紫外线辐射四个参数对微生物生长影响的测定结果。 在所研究的四个物种中——黑曲霉、枝孢枝孢、橙橙青霉和产黄青霉, 其中一种菌株黑曲霉是最稳定的, 能够在各种温度和介质 pH 值范围内、在紫外线辐射下活跃生长。

关键词: 微真菌、光和紫外线辐射、酸度、纸张。

**Annotation.** *Fungi in the air of library storages and on the surface of books pose a danger to the paper of documents, the leather of bindings and for keepers and librarians. Certain properties of fungi characterize their resistance to adverse environmental conditions and, consequently, survive in libraries and cause bio-damage to books. The results of determining the influence of four parameters — acidity of the medium, temperature, light and ultraviolet radiation on the growth of micromycetes, that have the high frequency of appearance in the repositories of libraries and archives, are presented. Of the four species studied — *Aspergillus niger*, *Cladosporium cladosporioides*, *Penicillium aurantiogriseum* and *Penicillium chrysogenum*, one stain *Aspergillus niger* was the most stable, able to*

grow actively in a wide range of temperatures and pH values of the medium, under the exposure to ultraviolet radiation.

**Keywords:** micromycetes, light and ultraviolet radiation, acidity, paper.

There are various types of microorganisms — bacteria and micromycetes — in the stocks of libraries, archives and museums, both in the air and on the surface. Micromycetes (mold fungi) pose a danger to the paper of documents and the leather of bindings. Not all micromycetes isolated from documents cause biodegradation. The most dangerous species are those that produce enzymes: protease, amylases, cellulases that destroy skin and parchment, binders, paper and wooden covers of bindings. More than 90 types of micromycetes are known to form pigments when growing on paper [1]. Forty historical parchments were collected from different institution, twelve of them were suspected to be infected by microorganisms due to visible color change on the surface of the parchment. The detected fungi were *Aspergillus niger*, *A. flavus*, *Penicillium funiculosum* and *Trichoderma viride* [2]. The genera *Cladosporium*, *Penicillium* and *Aspergillus* prevailed in the interior and on the surfaces in all libraries [3, 4, 5]. Six species of fungi were isolated from damaged books: *A. aspergillus niger*, *A. tamari*, *A. flavus*, *P. georgiense*, *P. citrinum* and *Tricoderma atroviride*, with *P. georgiense* never associated with paper, and *A. tamari* presumably participated in the degradation of ink [6]. Sometimes only two or three species were isolated from damaged books: *Cladosporium cladosporioides* and *P. chrysogenum* – the only types of damaged books printed in 1870 [7]. Of the 26 species of mycelial fungi found in the Cuban archives, only five were found both in the air and on documents: *Aspergillus flavus*, *A. niger*, *A. terreus*, *Cladosporium herbarum*, *Penicillium chrysogenum* [8]. *C. cladosporium* was the dominant constituent in the one of the sampling period, followed by *Penicillium* and *Aspergillus*, while in the next period prevailed *Penicillium* followed by *Cladosporium* and *Aspergillus* [4]. Given the danger of fungi to books and staff, various methods are used to inactivate them, including biocides, gamma radiation, and ultraviolet radiation. However, more stringent conditions are required to inhibit fungi in each case. Yeast fungus have the same resistance to UVC as *Candida albicans* fungi and are much more resistant than other bacteria or viruses [9]. Triple irradiation with a total dose of MJ/cm did not have an inhibitory effect on the micromycetes *A. niger*, *Alternaria alternate* and *Fusarium moniliforme*, and exposure to incoherent pulsed radiation completely inhibited their viability [10].

The micromycetes most commonly found in libraries, including the Russian National Library, were selected for the study: *Aspergillus niger* Tiegh. (frequency of appearance, FA=21), *Cladosporium cladosporioides* (Fresen.) G. A. de Vries (FA=11), *Penicillium aurantiogriseum* Dierckx (FA=16), и *Penicillium chrysogenum* Thom. (FA=13) [11, 12].

The influence of four parameters (acidity of the medium, temperature, light and ultraviolet radiation) on the growth of four micromycetes isolated from the surface of documents was studied.

On the agarized and in the liquid medium of Chapek-Dox with pH values from 3 to 9, all the studied micromycetes grew to one degree or another.

The growth of micromycetes was studied at different pH values. The radial growth rate on the agarized medium was determined by the diameter of the colonies over a certain period of time using the formula:  $Kg = (d_2 - d_1) / (t_2 - t_1)$ , where  $Kg$  is the radial growth rate, mm / day;  $d_1$  and  $d_2$  are the diameter of the colonies, mm;  $t_1$  and  $t_2$  are the initial and final moments of time measurements, respectively, a day.

*A. niger* was the most active: the growth rate after three days at a pH of 3 to 4 was 5-6 mm/day, at a pH of 5 to 9 — 7-12 mm/day, further growth slowed down on a medium with a pH of 3 to 5 to 1-2 mm / day, with a pH of 8-9 to 7-10 mm / day, and then on 10-14 days the growth rate decreased sharply to 0.5 mm / day.

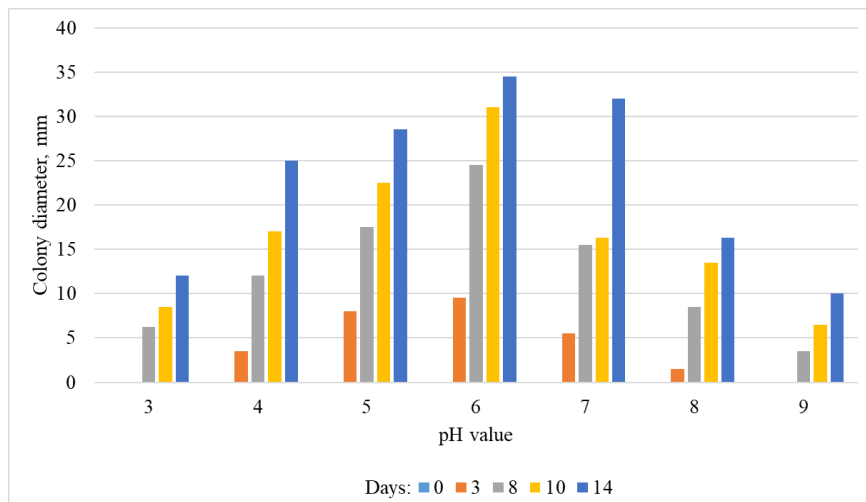
The size of colonies of the fungus *P. chrysogenum* in the first three days on all media increased at a rate of 3-4 mm / day, then on the medium with pH 8 and pH 9, the growth rate remained at the same level, for pH 3-5 decreased to 1 mm / day. The growth rate of *Penicillium aurantiogriseum* colonies was the most uniform for 14 days: in the first three days on all media it was on average 2-3.5 mm/day, then about 2 mm/day.

The most sensitive to the acidity of the medium was *Cladosporium cladosporioides*: on a medium with pH 3 and pH 9, the growth of the fungus was slowed down: on day 3 there was no growth at all, only on day 7-8 the colonies grew to 3-6 mm and then developed at a rate of about 1 mm / day. On a medium with a pH from 4 to 7, a relatively uniform growth rate of the fungus was observed, not exceeding 4 mm / day.

The largest diameter of colonies on day 14 in *Aspergillus niger* was on a medium with a pH from 6 to 9 — 76 mm, in *Penicillium chrysogenum* at a pH of 8-9 — 49 mm, in *P. aurantiogriseum* at a pH of 6 — 47 mm, in *C. cladosporioides* at a pH of 5 to 7 — 34 mm (picture 1).

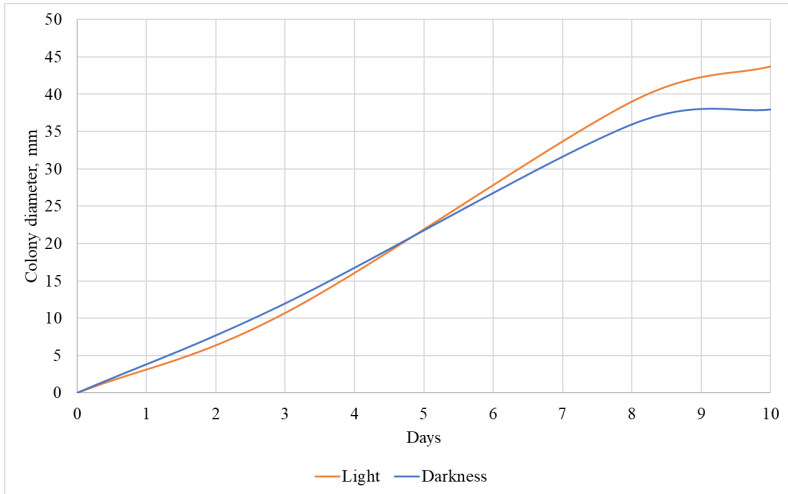
For comparison, the development of micromycetes with a concentration of 100,000 spores/ml in a liquid nutrient medium was studied. Growth was revealed mainly on the fifth day. *A. niger* actively grew on a medium with a pH from 3 to 6, less — with a pH from 7 to 9. *P. aurantiogriseum* developed moderately and evenly at all values of acidity of the liquid medium, *P. chrysogenum* and *C. cladosporioides* at all pH values except 5 and 6, the growth was insignificant. The change in the color of the medium from transparent to very pale yellow was noted in test tubes with a medium with pH = 9.

With deep growth of micromycetes *P. aurantiogriseum*, *P. chrysogenum* and *C. cladosporioides* at pH 8-9, light yellow staining of the medium was observed.



**Picture 1.** Growth of *Cladosporium cladosporioides* at different values of pH during fourteen days

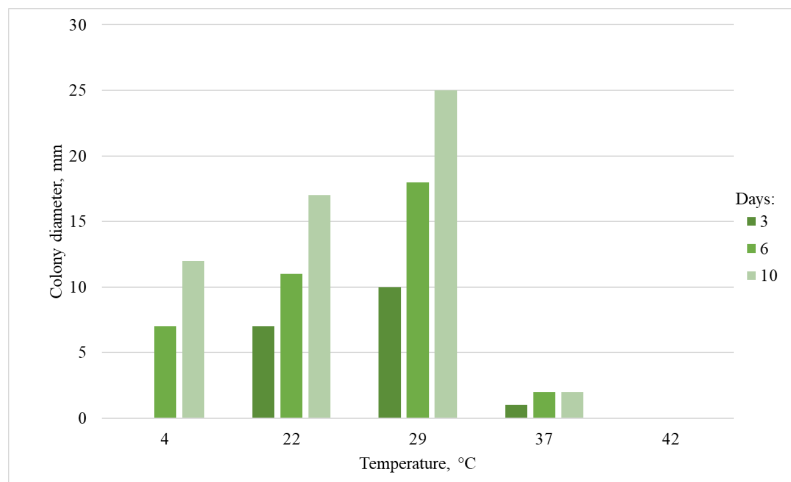
Books are usually stored in the dark and therefore it is interesting to compare the growth of fungi in the dark and in the sunlight. Petri dishes with spore-bearing colonies of micromycetes were kept in the light and in the dark. In the absence of light, *Aspergillus niger* had intense sporulation, a large colony area (17-19 mm) (picture 2), in addition, a light-yellow pigment was released. In the light, sporulation was insignificant, the colony size was 5-7 mm, there was no pigmentation. In the dark and in the light, *Penicillium chrysogenum* had the same growth rate, but in the dark, was intense olive — colored sporulation, and the formation of a bright yellow pigment on an agarized medium. In the light, the sporulation of the other color was insignificant, the pigmentation was pale yellow. In the dark, *P. aurantiogriseum* had more intense sporulation and a larger colony area, as well as a light yellow pigment in the agar medium, sporulation was insignificant in the light, there was no pigmentation at all. The color of the colonies of *Cladosporium cladosporioides* was dark olive in the light, black in the dark, the growth rate and size of the colonies were also larger in the absence of light.



**Picture 2.** Growth of *Aspergillus niger* in light and darkness during ten days

Hence, in all types of fungi, both the growth rate and pigmentation were significantly higher in the absence of light, which means that in conditions of high humidity, that is, in conditions favorable for the growth of fungi, their growth and pigmentation of the paper of books is possible.

Books should be stored at a temperature of 16-20°C in order to have comfortable conditions for librarians, but low temperatures are desirable for better preservation of documents. Most of the fungi in libraries are mesophiles. The activity of fungi was studied in the temperature range from +4 to 42°C. For *C. cladosporioides*, the optimal growth temperature was 22°C, at temperatures of 4 and 29°C — moderate growth, and at temperatures above 39°C there was no growth at all. *Aspergillus niger*, on the contrary, barely grew at 4 °C, actively at all temperatures, and most actively at 42 °C. Both *Penicillium* species showed moderate growth at a temperature of 4 °C, had different optima at 22 and 29°C, and practically did not grow at 37 °C. It should be noted that the growth of microorganisms at a temperature of 37 °C indirectly indicates their conditional pathogenicity. *A. niger* was the only fungi capable of growing at 42 °C. The temperature diagram of *Penicillium aurantiogriseum* is given as an example (picture 3).



**Picture 3.** Growth of *Penivillium aurantiigriseum* at different temperatures during ten days

Micromycetes were irradiated with harsh ultraviolet radiation for several hours until an individual lethal dose for each species was achieved. Fungi spores were placed on Petri dishes with a dissecting needle and the cup was placed under a bactericidal lamp. After irradiation, the dishes were placed in a thermostat and grown at a temperature of 27°C. The diameter of the colonies was measured on days 4, 7, 10 and 14 and compared with the control, the growth of an unirradiated fungus. After one hour of irradiation (2000 MW/m<sup>2</sup>), all the fungi were viable, after two hours (3500 MW/m<sup>2</sup>), all grew, but at different rates. On the fourteenth day, the growth was in the following sequence of activity (as it decreased): *A. niger*, *P. chrysogenum*, *P. aurantiigriseum*, *Cladosporium cladosporioides*. Triple irradiation did not have an inhibitory effect on the *A. niger*, either [10]. At a dose of 5000 MW/m<sup>2</sup> — irradiation for three hours, all fungi did not show growth.

Thus, the micromycetes most commonly found on documents are able to grow at low relative humidity and are extremely hardy in extreme conditions. For such resistant species, special methods are being developed to inhibit their growth, including higher concentrations of fungicides.

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糖尿病足综合症。西洛他唑制剂作为复杂药物支持一部分的作用的临床研究  
**DIABETIC FOOT SYNDROME. CLINICAL STUDY OF THE ROLE  
OF CILOSTAZOL PREPARATIONS AS PART OF COMPLEX DRUG  
SUPPORT**

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抽象的。为了检验西洛他唑药物临床使用过程中可能出现并发症的假设，我们在喀山医科大学诊所糖尿病足中心针对糖尿病足综合征患者进行了抗血小板西洛他唑及其类似物并发症发生频率的临床研究。该研究比较了西洛他唑的两种类似物。根据获得的类似物，将患者分为代表初始数据的 2 组。在这些组中，比较了副作用的频率、有利和不利结果的频率。

关键词：糖尿病、糖尿病足综合征、慢性动脉供血不足、西洛他唑、Aducil®、Pletax®。

**Abstract.** *In order to test assumptions about possible complications during the clinical use of cilostazol drugs, we conducted a clinical study of the frequency of complications of antiplatelet cilostazol and its analogues in patients with diabetic foot syndrome at the Diabetic Foot Center of the Kazan Medical University Clinic. The study compared 2 analogues of cilostazol. The patients were divided into 2 groups representative of the initial data, in accordance with the analogue obtained. In these groups, the frequency of side effects, the frequency of favorable and unfavorable outcomes was compared.*

**Keywords:** *diabetes mellitus, diabetic foot syndrome, chronic arterial insufficiency, cilostazol, Aducil®, Pletax®.*

**Introduction:** Diabetes mellitus, according to the World Health Organization, is one of the four priority non-communicable diseases with a high risk of complications [1]. It must be understood that diabetes mellitus is not a separate isolated disease and damage to the macroorganism. It is a “non-condition” that is characterized by multifocal lesions in their clinical manifestation. Damage to the arterial bed in diabetes mellitus is morphologically atherosclerosis, which, however, has a number of distinctive features: the lesion is more distal in nature, bilateral and multiple localization of stenoses, the development of the pathological process at a younger age, the incidence of the disease is comparable by gender [2]. The process also involves vessels located next to the occlusion. This prevents reliable compensation of tissue ischemia due to disruption of the functioning of the collateral vascular network [2]. The ischemic component in the lower extremities in diabetes mellitus progresses much faster, and pain when walking does not always occur. The equivalents of pain in diabetic foot syndrome (DFS) are a feeling of weakness and fatigue of the leg muscles [2].

One of the main components of disruption of the cascade of metabolic processes and the function of organs and systems in diabetes mellitus and, in particular, in diabetic foot syndrome is the clinical manifestation of angiopathy and neuropathy, as a consequence of microangiopathy. A decisive role in this is played by negative regulators in the signaling cascade of cyclic nucleotides – phosphodiesterases [3]. Cilostazol, as an inhibitor of the phosphodiesterase group [4] and an antiplatelet agent, is among the drugs recommended for diseases of the arteries of the lower extremities [5].

Purpose of the work: to clinically identify and compare the number of complications when using two analogues (“aducyl” and “pletax”) of cilostalosis, as selective inhibitors for different families of PDEs. Based on the obtained results of clinical data, interpret: 1. Therapeutic /favorable and unfavorable/ effects and side effects when using cilostazol, 2. Detail the types and frequency of manifestation of complications during the clinical use of cilostazol analogues in complex therapy for diabetic foot syndrome.

Materials and methods: taking into account the data we obtained from a molecular study of the effect of cilostazol [4] and in order to test the assumptions based on them, we, at the Department of Surgical Diseases of the Kazan State Medical University, conducted a clinical study of the frequency of complications of the antiplatelet agent cilostazol and its analogues in patients with diabetic foot syndrome. As analogues, we selected two drugs with trade names: “aducyl” (group A) and “pletax” (group P). A comparison of cilostazol and pentoxifylline analogues was not carried out in this study, as it is indicated in the known literature [5,6].

The study on the significance of clinical results included 165 patients (p) with diabetic foot syndrome, with level of arterial damage 2A-2B, distal sensorimo-

tronic neuropathy moderate or severe, according to the VAT scale and tissue damage W1-2-3, who received treatment using the technology of the “diabetic foot” center in Kazan with the inclusion of cilostazol /aducyl/ (group A) and cilostazol /pletax/ (group P) in the regimen for a certain time period of 2020-2021. The patients were distributed into two groups, representative of the initial data (Table 1).

**Table 1.**  
*Composition of the study groups.*

	Average age	Gender composition	Depth of tissue damage	Degree of damage to the arterial bed
Group A (n=89)	62,4 ± 8,7	M – 41 F – 48	W1 – 39 (43,8%) W2 – 31 (34,8%) W3 – 19 (21,4%)	KHAN 2A – 46 (51,7%) KHAN 2B – 43 (48,3%)
Group P (n=76)	61,75 ± 7,5	M – 34 F – 42	W1 – 31 (40,8%) W2 – 29 (38,2%) W3 – 16 (21%)	KHAN 2A – 42 (55,3%) KHAN 2B – 34 (44,7%)

Criteria for inclusion in the study: male and female patients aged 21 years inclusive (at the start of the study) with a neuroischemic form of diabetic foot syndrome, manifestation of type 2 diabetes mellitus from 10 to 5 years, absence of clinical evidence of chronic venous insufficiency of the lower extremities, absence of indications for reconstruction of the arteries of the lower extremities, the depth of damage to the tissue structures of the feet, according to the classification according to F.W. Wagner (1981) [7] 1-2-3, oxygen tension in the tissues immediately adjacent to the area of the ulcerative defect, from 22 to 40 mm Hg, neurological deficit on the VAT scale (Table 2) 7-14 points, patients with no urgent indications for amputation of a limb, the patient’s willingness to comply with the requirements for examination and treatment, the availability of written informed consent from the patient.

Criteria for not being included in the study: chronic ischemia of the lower extremities of a non-atherosclerotic nature (other than diabetes mellitus): vasculitis, systemic connective tissue diseases, Buerger’s disease, congenital anomalies and vascular injuries, embolism; neuropathic form of diabetic foot syndrome, severe neuroosteoarthropathic foot deformity, critical ischemia of the lower extremities, ischemia threatening the loss of a limb, the presence of purulent destructive lesions of the foot (abscess, phlegmon, osteomyelitis, etc.), skin changes associated

with venous pathology, proliferative and end-stage diabetic retinopathy, glycosylated hemoglobin level at study entry greater than 11%, diabetic ketoacidosis or diabetic precoma, systemic use of glucocorticosteroids, recent (less than 6 months) surgery or endovascular intervention on the arteries of the lower extremities, recent (less than 6 months) cases of acute myocardial infarction, unstable angina, coronary artery bypass grafting or coronary artery stenting, stroke or transient ischemic attack, severe concomitant illness with a life expectancy of less than a year, an established oncological diagnosis within the last 5 years.

The diagnostic algorithm for identifying arterial insufficiency included the following stages [8]: study of arterial pulsation by palpation, determination of the level of glycosylated hemoglobin (HbA1c) (hemoglobin that does not have an oxygen transport function), ultrasound of the arteries of the extremities, transcutaneous pulse oximetry and determination of the partial pressure of oxygen in the tissues (oximetry).

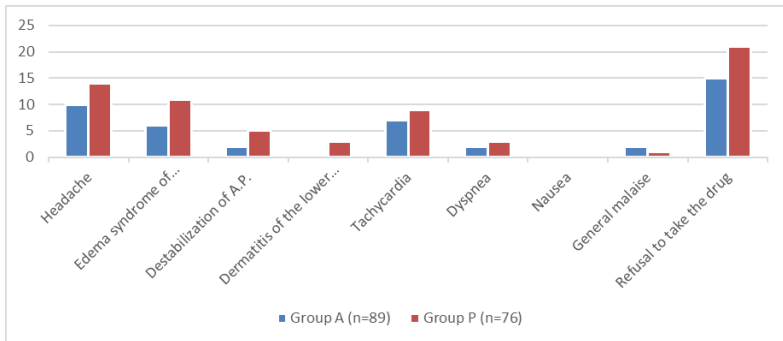
The level of damage to the arterial bed was determined according to the classification of chronic arterial obstruction according to Fontaine - A.V. Pokrovsky [9]. If damage to the arterial vascular system was detected in a patient, the patients were sent to the department of vascular surgery and/or the department of x-ray surgical methods of diagnosis and treatment. Indications/contraindications for arterial revascularization were determined based on the TASCII recommendations [10].

Neurological deficit was determined by determining the severity of diabetic peripheral neuropathy in accordance with the Neuropathic Dysfunctional Score [11].

Results. Patients in both groups received identical drug therapy [12], taking into account the pathogenesis of pathological changes in DFS and focusing on national standards and clinical recommendations for the provision of medical care to patients with diabetic foot syndrome, against the background of hypoglycemic therapy. Patients in both groups used the implemented "step-by-step medical-surgical approach" technique [13]. The course of treatment was carried out for 4 months. The dose of the drugs was 100 mg 2 times/day per os. Termination of the course of treatment before the specified dates with the inclusion of forms of cilostazol was carried out upon the patient's request to refuse treatment. The clinical relevance of research results is a fundamental principle. It is based on the effectiveness and outcome of treatment. A true clinical outcome is a clinical manifestation that has significant meaning for the patient [14]. An indirect assessment criterion is laboratory parameters and/or symptoms that replace a clinically significant outcome [15]. To assess the results of treatment, we used clinically significant values for patients - outcomes: favorable and unfavorable [15]. Unfavorable signs included the occurrence of one or more complications and/or the patient's personal refusal to take cilostazol analogues due to individual intolerance (Table No. 2, Fig. 1).

**Table 2.**  
*Complications verified in the study groups.*

	<b>Group A (n=89)</b>	<b>Group II (n=76)</b>
Headache	10 (8,9 %)	14 (18,4%)
Edema syndrome of the lower extremities	6 (6,7%)	11 (14,5%)
Destabilization of A.P.	2 (2,2%)	5 (6,6%)
Dermatitis of the lower extremities	0 (0%)	3 (3,9%)
Tachycardia	7 (7,9%)	9 (11,8%)
Dyspnea	2 (2,2%)	3 (3,9%)
Nausea	0 (0%)	0 (0%)
General malaise	2 (2,2%)	1 (1,3%)
Refusal to take the drug	15 (16,8%)	21(27,6%)



**Figure 1.** *Complications verified in the study groups (sign the far right column)*

The obtained data on patient observation outcomes were entered into a contingency table (Table 3).

**Table 3.**  
*Contingency table of treatment outcomes for the study groups.*

<b>Contingency table of outcomes</b>			
Group	Number of patients		
	With a favorable outcome	With an unfavorable outcome	Totally
Group A (n=89)	A (n=71)	B (n=18)	A+B (n)
Group II (n=76)	C (n=47)	D (n=29)	C+D (n)

The interpretation of the obtained clinical data on treatment outcomes is based on a mathematical model in which the following indicators were taken into account (according to calculation formulas) [14]:

1. Relative frequency of favorable outcomes in group A (FFOgA) =  $A / (A+B) \times 100\%$ ,
2. Relative frequency of favorable outcomes in group P (FFOgP) =  $C / (C+D) \times 100\%$ ,
3. Frequency of adverse outcomes in group A (FAOgA) =  $B / (A+B)$ ,
4. Frequency of adverse outcomes in group P (FAOgP) =  $D / (C+D)$ ,
5. Reduction in the relative risk of the study groups (RRRSG) =  $(FAOgP - FAOgA) \times 100\%$ ,
6. Increase in relative benefit (IRB) - this indicator was defined as a relative increase in the frequency of favorable outcomes in group A relative to group P according to the formula:  $IRB = (FAOgA - FAOgP) / FAOgP \times 100\%$ .

#### Conclusions:

When comparing the results of treatment of patients in group A (using aducyl) and group P (using pletax) according to the presented model, taking into account the outcomes that were significant for the patients themselves, we obtained the following data:

1. There is a higher level of clinically verified complications in patients in group P
2. The relative frequency of favorable outcomes for group A was 79.7%
3. The relative frequency of favorable outcomes in group P was 61.8%
4. The frequency of adverse outcomes in group A was 0.202
5. The frequency of adverse outcomes in group P was 0.381
6. The reduction in the relative risk of the studied groups was 17.9%
7. In the clinical use of cilostazol analogues in the complex treatment of patients with diabetic foot syndrome, the least side effects were verified for the drug Aducil® in comparison with the drug Pletax®, with an increase in the relative benefit of using the first in relation to the second by 28.9%.

There is no conflict of interest.

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具有功能特性的现代合成生物塑料材料在糖尿病足综合征溃疡缺损手术中的应用

**MODERN SYNTHETIC BIOPLASTIC MATERIALS WITH  
FUNCTIONAL PROPERTIES IN THE SURGERY OF ULCERATIVE  
DEFECTS OF DIABETIC FOOT SYNDROME**

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抽象的。 本文描述了一种解决现代外科优先问题之一的原创方法：皮肤和软组织营养缺陷的治疗。 该问题的相关性是由于营养缺陷发病机制的模糊性、在保守治疗和耐药性背景下复发和体积增加的趋势、患者生活质量的恶化、营养缺陷的复杂性和持续时间。 治疗，以及治疗和康复的巨大经济成本。 导致软组织形成广泛丧失的缺陷显着影响生活质量，需要一种新的手术方法来治疗这种病理。

关键词：糖尿病足综合征，重建手术，伤口缺损的形态测量。

**Abstract.** *The article describes an original approach to solving one of the priority problems of modern surgery: the treatment of trophic defects of the skin and soft tissues. The relevance of the problem is due to the ambiguity of the pathogenesis of trophic defects, the tendency to relapse and increase in volume against the background of conservative treatment and resistance to it, deterioration in the quality of life of patients, the complexity and duration of treatment, and significant economic costs for treatment and rehabilitation. Defects that lead to extensive loss of soft tissue formations significantly affect the quality of life and require a new approach to the surgical treatment of this pathology.*

**Keywords:** *diabetic foot syndrome, reconstructive surgery, morphometry of the wound defect.*

**Introduction.** One of the priority problems of modern surgery for diabetic foot syndrome is the treatment of trophic defects of the skin and soft tissues. Active surgical tactics in patients with tissue defects in diabetic foot syndrome are necessary due to the ability to most actively influence the processes of restitution and regeneration. It has been proven that in patients with DFS, the amount of collagen produced by fibroblasts decreases, which leads to a slowdown and/or impossibility of reducing the wound defect [1].

**Materials and methods.** At the clinical bases of the Department of Surgical Diseases of the Kazan State Medical University, as part of a complex local impact on the wound process, a technique for the use of combined bioplastic materials in the surgery of wound defects in SDS has been developed and introduced into practice [2], since 2019, in combination with the implantation of autologous growth factors (AGFs). The use of AGF stimulates regeneration processes, leading to faster and better scar formation, reducing the risk of recurrence of the wound process. Currently, the most common in practical surgery are bioplastic materials of the matrix-plastic group; such materials can be defined as “biodegradable wound coverings with functional properties.” One of the representatives of which is the modern domestic histoequivalent bioplastic material “G-DERM” (Gee Derm), obtained using the technology of chemical modification of hyaluronic acid and the biosynthesis of additional protein components. This avoids the disadvantages and dangers of native collagen biomaterials. When creating modern structures for reconstructive and plastic surgery, hyaluronic acid (HA), a glycosaminoglycan, a natural component of the extracellular matrix of vertebrate tissues, is often used [3,4]. Possessing high hydrophilicity and multipolarity, the HA molecule promotes the formation of an optimal extracellular matrix for the restoration of affected organs, preventing fibrosis and the formation of scar contractures [5]. The histoequivalent bioplastic material is a lamellar polymer (90% hyaluronic acid and 10% collagen).

The first stage in the treatment of patients with ulcerative defects of the lower extremities is debridement of the defect [5]. Debridement of the wound defect is carried out by hardware ultrasonic hydrosurgical treatment until “blood dew”. Then we apply the biomaterial to the wound surface according to the existing method: before applying it to the wound surface, the biomaterial plate is either abundantly irrigated with NaCl 0.9% solution to moisturize it or completely immersed in a tray with NaCl 0.9% solution. The maximum exposure was up to 3 minutes. The material is modeled according to the shape and size of the wound, taking into account the protrusion beyond the edges of the defect by 5 - 10 mm. The application is made with the smooth side facing the surface of the wound defect. The biomaterial takes the form of an elastic membrane and fits tightly to the underlying tissues. The material remains on the wound until the plate is complete-

ly biodeconstructed, after which the biomaterial is re-applied. Repeated application is carried out on average 7-9 days [2,5].

One of the main properties of biomaterial is controlled biological destruction; it directly correlates with the conditions of tissue blood circulation[6], their innervation and the presence of moistwoundhealing conditions (wet wound healing). In addition to the application of biomaterial, we use the introduction of AGF into the tissue of the defect (bottom, walls, edges) to a depth of 5 mm in a “checkerboard pattern” to 0.3-0.5 in one injection. Preimplantation preparation of AGF was carried out according to a patented technique. The introduction of growth factors into tissues was carried out through the structure of the biomaterial with the interval: 0-3-5-7 and 9 days after the primary operation.

Based on the principles of “evidence-based medicine,” we conducted a clinical and morphometric study, on the basis of which we constructed a model for assessing the effectiveness of the use of matrix-plastic biodegradable materials in patients with tissue defects in diabetic foot syndrome. The study included 177 patients (n) with diabetic foot syndrome, who had verified tissue defects with damage levels W2 - W4, who received treatment using the technology of the Department of Surgical Diseases (main group) and according to the standard principles of purulent surgery departments (comparison group) for a certain time period 2021/2022. The patients were divided into two groups, representative of the initial data (Table 1)

**Table 1.**  
*Groups of patients, characteristics of wound defects.*

	<b>Average age</b>	<b>Gender composition</b>	<b>Depth of tissue damage</b>	<b>Degree of damage to the arterial bed</b>
Main group (n=49)	63,4 ± 7,6	M – 14 F – 35	W2 – 19 (38,8%) W3 – 9 (18,4%) W4 – 21 (42,8%)	KHAN 2 – 16 (32,7%) KHAN 3 – 10 (20,4%) KHAN 4 – 23 (46,9%)
Comparison group (n=126)	65,75 ± 8,2	M – 42 F – 84	W2 – 59 (46,8%) W3 – 29 (23%) W4 – 38 (30,2%)	KHAN 2 – 38 (30,2%) KHAN 3 – 9 (7,1%) KHAN 4 – 79 (62,7%)

To assess the results of treatment, we used clinically significant values for patients - outcomes: favorable and unfavorable [7,8]. Favorable outcomes included: epithelization of the defect, relief of clinical signs. Unfavorable outcomes: non-healing of the defect, complications, amputation at the level of the foot and above, death of the patient.

**Table 2.**  
*Contingency of outcomes.*

Group	Number of patients		
	With a favorable outcome	With an adverse outcome	Totally
Main	A (n=49)	B (n=0)	A+B (n=49)
Comparisons	C (n=107)	D (n=19)	C+D (n=126)

We took into account the following indicators [6]:

1. Frequency of favorable outcomes in the main group (FFOMG) =  $A/(A+B)$ ,
2. Frequency of favorable outcomes in the comparison group (FFOCG) =  $C/(C+D)$ ,
3. Reduction in the relative risk of the study groups (RRRSG) =  $(CHNIOG-CHNIOG) \times 100\%$ ,
4. Increase in relative benefit (RIB) - this indicator was defined as a relative increase in the frequency of favorable outcomes in the main group compared to the control group using the formula:  $RBIG = (FFOMG - FFOCG)/FFOCG \times 100\%$

When interpreting the research results, according to the above formulas, we obtained the following data:

1. The frequency of favorable outcomes in the main group was 92%, in the comparison group 77%,
2. The reduction in the relative risk of adverse outcomes when using the proposed technique was 15%,
3. The increase in the relative benefit of the proposed technique was 19.5%.

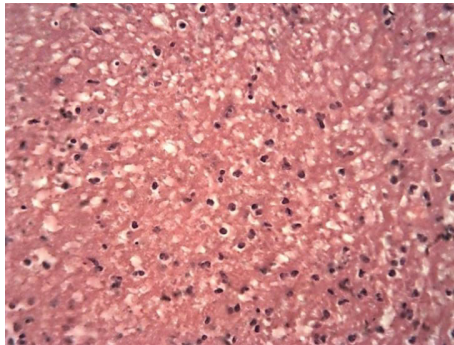
Results. During 2021-2022, on the basis of the Department of General Pathology of the Federal State Budgetary Educational Institution of Higher Education “Kazan State Medical University” of the Ministry of Health of Russia, a histological and immunohistochemical study of biopsy material was performed after using the “G-DERM” biomaterial.

Biopsies were fixed in 10% neutral formalin according to Lilly or Bowen’s fluid. According to the generally accepted method, after appropriate treatment with alcohols of increasing concentrations, treatment in xylene and embedding in paraffin followed. Paraffin sections with a thickness of 4-5  $\mu\text{m}$  were prepared using a Leica SM 2000R microtome. The resulting preparations were stained with hematoxylin and eosin, as well as van Gieson. For immunohistochemical studies, a set of monoclonal antibodies (mCAT) was used, the characteristics of which are presented in Table 3.

**Table 3.**  
*Characteristics of the monoclonal antibodies used*

antigen	clone	specificity	working dilution	company manufacturer
myeloperoxidase	polyclonal, code RB-373-A	neutrophilic leukocytes	1:800	Dako
vimentin	V9	fibroblasts	1:300	Lab Vision
pancytokeratins	AE1/AE3	epithelium	1:300	Lab Vision
CD 31	9611	endothelium vessels	1:20	BioGenex

The binding of mAb to cellular elements was determined using the standard biotin-streptavidin-peroxidase method (DAKO: LSAB® + System-HRP, code K0690) with diaminobenzidine as chromogen. The preparations were additionally stained with Mayer's hamatoxylin and placed in Canada balsam or in special media from DAKO (Ultramount, Faramount, code S302580-2). As a result of a morphological study, it was established that on day 1 the histological structure of the bioplastic film covering the ulcerative defect was represented by an amorphous cellular eosinophilic matrix without any inclusions. Immunohistochemically, the biomaterial was also intact. In the underlying tissues there was focal or diffuse inflammatory cell infiltration, areas of necrosis and hemorrhage. On day 7, in all observations, there was a pronounced cellular infiltration of the bioplastic film, which was tightly adjacent to the area of the ulcerative defect. Neutrophils, lymphocytes, macrophages and fibroblasts were detected here (Fig. 1).

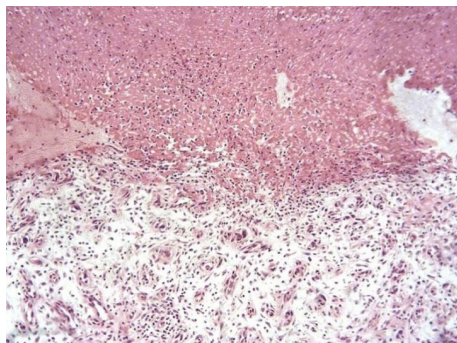


**Figure 1.** *Histological structure of biomaterial with cellular infiltration.*

Hematoxylin and eosin staining. x 400.

The latter were determined immunohistochemically by mAb against vimentin. At the same time, the reaction of mCAT against pan-cytokeratins was negative.

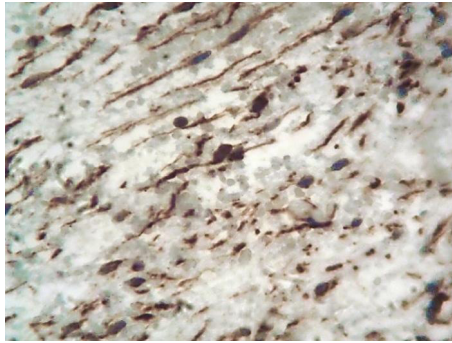
In some cases, the infiltrate was represented predominantly by neutrophilic leukocytes. In the underlying tissues, the phenomena of inflammation with necrosis persisted, but unlike the previous observation period, there was an accumulation of mesenchymal cellular elements at the border with the biomaterial. At 14 days, a tight connection of the bioplastic film with the underlying tissues was determined. At the junction border, proliferation of fibroblasts and proliferation of collagen fibers were observed with the formation of granulation tissue under the film (Fig. 2).



**Figure 2.** Proliferation of granulation tissue under a film of biomaterial.

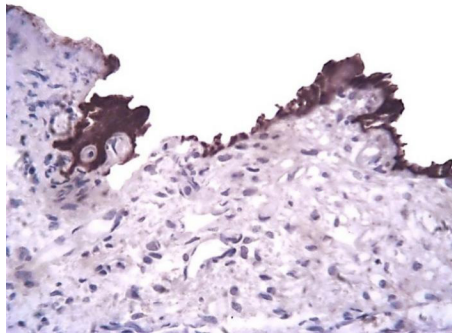
Hematoxylin and eosin staining. x 200.

In the biomaterial itself, the intensity of cellular infiltration decreased and the composition of the infiltrate changed. Thus, there were practically no neutrophils, macrophages and lymphocytes were found, and fibroblasts were the predominant population, which was confirmed by the mCAT reaction against vimentin. In addition, immunohistochemical analysis revealed individual epithelial cells - keratinocytes. In the underlying tissues, the inflammatory reaction subsided with a decrease in the volume of necrosis and the beginning of reparative processes. This was expressed in the proliferation of blood vessels with the development around connective tissue structures similar to the formation of granulation tissue. On day 21, the biomaterial, significantly modified compared to the original matrix, completely covered the surface of the ulcerative defect. It merged with the underlying tissues without a clear boundary. In large areas, it was reabsorbed with replacement by fibroblastic cellular elements and fibrous structures. Signs of inflammation and necrosis were practically absent. Transformation of granulation tissue into connective tissue occurred, which was accompanied by a pronounced reaction of mCAT against vimentin (Fig. 3).



**Figure 3.** Reaction with mAb against vimentin in fibroblasts. LSAB method with hematoxylin staining. x 400.

Immunohistochemical analysis also showed an increase in the expression of mAbs against pan-cytokeratins in epithelial cells. In this case, keratinocytes, in contrast to the previous observation period, often covered the surface of the defect in the form of a continuous layer (Fig. 4).



**Figure 4.** Formation of a layer of epithelial cells on the surface of the transformed biomaterial. Reaction with mCAT against pancytokeratins. LSAB method with hematoxylin staining. x 400.

Conclusions. 1. The frequency of favorable outcomes in the main group was 92%, in the comparison group 77%, 2. The frequency of unfavorable outcomes in the main group was observed in 8% and in the comparison group in 23% of patients, 3. Reduced relative risk of adverse outcomes when using the proposed technique was 15%, 4. The increase in the relative benefit of the proposed technique was 19.5%, 5. The average length of stay of a patient in hospital was 5.6

days shorter in patients of the main group, 6. Application of the medical product “Histo-equivalent-bioplasic material “G-DERM” “(Gee Derm)” in patients with trophic defects of soft tissues in diabetic foot syndrome contributes to a significant reduction in the inflammatory reaction in the underlying tissues, the absence of complications in the form of destruction and necrosis, as well as the development of reparative regeneration processes on the 21<sup>st</sup> day of use.

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糖尿病足综合征手术路线图诊断阶段的管理和组织  
**MANAGEMENT AND ORGANIZATION OF THE DIAGNOSTIC  
STAGE OF THE ROADMAP IN DIABETIC FOOT SYNDROME  
SURGERY**

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注解。糖尿病足综合征患者的医学可视化问题是现代外科手术的主要方向之一。本文考虑了这种病理学诊断主要阶段的算法和组织，这可以最大限度地减少器官破坏操作，并在实践中应用组织保存和下肢支撑功能保存的原则。

关键词：糖尿病足综合征，诊断算法，组织氧合，组织氧饱和度。

**Annotation.** *The problems of medical visualization in patients with diabetic foot syndrome are one of the main vector directions in modern surgery. The article considers the algorithm and organization of the main stage of diagnostics of this pathology, which allows to minimize organ-destroying operations and to apply in practice the principle of tissue preservation with preservation of the supporting function of the lower limbs.*

**Keywords:** *diabetic foot syndrome, diagnostic algorithm, tissue oxygenation, tissue oxygen saturation.*

### **Introduction**

According to the World Health Organization, diabetes mellitus and its complications is one of the four priority non-communicable diseases with a high risk of complications. The lesion of the arterial channel in diabetes mellitus morphologically represents atherosclerosis, which, however, has a number of distinctive features: the lesion is more distal, bilateral and multiple localization of stenoses, the development of the pathological process at a younger age, the incidence of

the disease is comparable by gender [1]. The vessels located near the occlusion are also involved in the process. This prevents reliable compensation of tissue ischemia due to impaired functioning of the collateral vascular network [1]. In addition, macroangiopathy in diabetes mellitus is clinically manifest as: ischemic heart disease and cerebrovascular disease. The ischemic component in the lower extremities in diabetes mellitus progresses much faster, while the pain syndrome when walking does not always occur. Pain is localized not in the lower legs, but in the area of the feet. The equivalents of pain in diabetic foot syndrome (DFS) are a feeling of weakness and fatigue of the lower leg muscles [1].

Due to multifocality of tissue and organ damage in diabetes mellitus (neuropathy, microangiopathy, macroangiopathy, osteoarthropathy, lymphovenous insufficiency), a number of vector problems are currently emphasized in the diagnosis and treatment of patients with DFS: 1. Selection of optimal methods of medical imaging with determination of further management tactics; 2. Formation of a “road map” (technology of obtaining information about the patient and deciding on treatment tactics); 3. Methods of general and local treatment, affecting all links of pathogenesis of this pathology, its stages and timeliness.

Diagnosis of the degree and types of foot function lesions in patients with diabetes syndrome is a difficult complex task. In our work we use our proposed scheme [3] of diagnostic algorithm for patients with DFS. At the same time, when creating the algorithm, we were guided by existing clinical recommendations. The proposed unified therapeutic and diagnostic complex makes it possible to promptly prescribe timely treatment and avoid severe irreversible consequences of the disease.

We determined the neurological deficit by determining the severity of diabetic peripheral neuropathy in accordance with the generally accepted scale of neuropathic dysfunctional count (NDC). Radiography of the feet and lower extremities is used to verify diabetic neuroosteoarthropathy and Menkeberg’s sclerosis. To determine the severity of diabetic angiopathy (assessment of blood flow and oxygen transport function) we use the following types of examinations: examination of pulsation of the main arteries by palpation, determination of glycolized hemoglobin (HbA1c) level (hemoglobin not possessing oxygen transport function), ultrasonic ultrasound of arteries of the extremities, transcutaneous pulse oximetry and determination of partial pressure of oxygen in tissues (oximetry). Angiography (contrast or carboxyangiography if there is a risk of contrast-induced nephropathy) is performed in patients admitted for treatment by angiosurgeons and/or endovascular surgeons.

Medical imaging methods

Real-time ultrasound (B-mode) allows visualization of fixed structures: the lumen and walls of the vessel, surrounding tissues, pathological processes. Thus,

assess the patency of the vessel, the level and degree of stenosis, the size of the vessel (normal, dilatation, hypoplasia), the presence of bends, deviations of the vessel, pulsation (normal, amplification, weakening, absence), intravascular changes (atherosclerotic plaque and its type, thrombus). Ultrasound Doppler ultrasonography (USDG), based on the reflection of ultrasound waves from moving objects, allows to obtain quantitative, qualitative and graphic data on the physiology of blood flow by the following indicators: linear blood flow velocity (LFV), the presence and degree of stenosis (with stenosis over 90% (critical narrowing) LFV reliably decreases to 0), the type of blood flow, the value of collateral blood flow (indirectly) [4]. Reliable signs of stenotic lesion are the detection of local narrowing of the arterial lumen with changes in pulsation (supra-stenotic strengthening and post-stenotic weakening) against the background of irregular thickening of the vessel wall throughout [4].

One of the most important characteristics of the state of the vascular bed of the foot in DFS is the index of oxygen saturation of the blood capillary bed. This can be determined by pulse oximetry performed with a transcutaneous pulse oximeter, which is based on the ability of hemoglobin bound ( $\text{HbO}_2$ ) and not bound to oxygen (Hb) to absorb light of different wavelengths. We consider oxygen saturation ( $\text{SpO}_2$ ) values of 90-92% or higher (toe area of the 2nd foot) to be normal for patients with DFS. These data were obtained empirically. In normality,  $\text{SpO}_2$  is equal to or greater than 95% [4]. Pulse oximetry data allow in practice to indirectly determine the indices of partial pressure of blood  $\text{O}_2$  ( $\text{PaO}_2$ ), which in the norm is 80-100 mmHg. A decrease in  $\text{PaO}_2$  is accompanied by a decrease in  $\text{SpO}_2$ : 80-100 mmHg.  $\text{PaO}_2$  corresponds to 95-100%  $\text{SpO}_2$ ; 60 mmHg.  $\text{PaO}_2$  corresponds to 90%  $\text{SpO}_2$ ; 40 mmHg  $\text{PaO}_2$  corresponds to 75%  $\text{SpO}_2$  [4]. Transcutaneous oximetry with assessment of tissue perfusion in the skin at the level of the back of the foot - partial tension of oxygen in tissues ( $\text{TcpO}_2$ ) is performed using an oximeter. Determination of this indicator is currently the only objective criterion for assessing tissue viability. By the level of which can be judged on the degree of endothelial dysfunction of the capillary channel. If the degree of damage of the latter is moderately pronounced, then  $\text{TcpO}_2$  on the foot and lower leg can be more than 40 mmHg even against the background of low  $\text{SpO}_2$ .  $\text{TcpO}_2$  has a high prognostic value with regard to the outcome of neuroischemic ulcers in DFS, assessment of the level of amputation, as well as wound healing. If  $\text{TcpO}_2$  in the foot is more than 40 mmHg, the prognosis is favorable, if it is less than 30 mmHg. - unfavorable. Decrease in dynamics of  $\text{TcpO}_2$  below 30 mmHg is a manifestation of increasing degree of tissue ischemia and increases the probability of high organ-killing surgery. The value of  $\text{TcpO}_2$  exceeding 30-40 mmHg can serve for determining the level of economical amputation and a favorable prognostic indicator of primary wound healing after the operation. In addition,  $\text{TcpO}_2$  values at different levels

allow determining the regional perfusion index (RPI), which is important for predicting the course of the wound process in the area of the extremities and predicting the outcome of treatment [5,6,7].

Counting formula:  $RPI = \text{TcpO}_2 (\text{limb}) / \text{TcpO}_2 (\text{torso})$ . Data interpretation:  $RPI < 0.4$  likely unfavorable outcome [6],  $RPI = > 0.6$  likely favorable outcome [6],  $0.4 < RPI < 0.6$  risk zone [6]

X-ray contrast angiography of the lower extremities remains the “gold standard” in the diagnosis of peripheral arterial pathology, used by angiologists before choosing the method of arterial reconstruction in almost 100% of cases. The method allows revealing signs and degree of arterial stenosis and occlusions, irregularity of their contours, level of vessel narrowing. Thus, in case of occlusion the “break” of the artery contour with irregular shape is visualized; in case of long-term ischemia of the lower limbs the intensity of the collateral vessels network is determined with the restoration of the artery shadow distal to the occlusion [4]. It is known that diabetic macroangiopathy is manifested by polisegmental stenoses of the arteries of the lower leg and foot with extended occlusions; atherosclerotic thickening of predominantly middle arterial sheath with vascular wall stiffness (arterial fragility). Distal stenoses make it difficult to perform both endovascular and open angiographic operations. Extended stenoses make it almost impossible to perform balloon angioplasty. This is usually associated with a gross lesion of endothelial lining of arteries, direct stimulating contact of platelets with collagen of the vascular wall and incomplete diagnosis of the degree of diabetic angio- and polyneuropathy in the preoperative period [4].

If it is technically impossible to perform arterial reconstruction in patients with DFS against the background of gangrenous process, they (according to vital indications) undergo organ-killing operations: high or low. In order to minimize the level of amputation in all patients, even with extensive gangrenous lesions (W5), we perform oximetry in the preoperative period [5,6,7], with the application of three sensors: foot/lower third of the tibia, middle third of the tibia, and upper third of the tibia. We determine the level of amputation according to tissue oxygen saturation indices.

### Clinical example

Patient G.Kh.A., born in 1953 (case history 4936/1163), was admitted to the clinic of the Department of Surgical Diseases of Kazan State Medical University with the following diagnosis: Diabetic foot syndrome, W5 on the right, neuroischemic form. Gangrene of the foot. Diabetic angiopathy, KHAN, 4th stage CINC. Condition after arterial reconstruction on the left. Systemic inflammatory reaction syndrome. Diabetic polyneuropathy distal sensory-motor and vegetative form. Menkeberg's sclerosis. Condition after metatarsal amputation of the left foot. DNAP, active stage, phase 1. IBS. Paroxysmal atrial fibrillation. Arrhythmio-

genic shock 1. GB. Stage 3. risk 4. CHF 1. FC 2. Type 2 diabetes mellitus, insulin-dependent, subcompensation, severe course. HbA1c > 10.0%. Retinopathy. Nephropathy. C3b CKD (CKD-EPI 37 ml/min/1.73 m<sup>2</sup>). The condition at the time of admission is extremely severe due to intoxication syndrome. According to relatives, he was ill for about 10 days, sharp deterioration for 3 days with the appearance of tissue defect. He did not consult a doctor during these days. Diabetes mellitus type 2 2 years. Retinopathy 1 year. History of X-ray endovascular vasodilation on the left side 1 year ago, metatarsal amputation of the left foot 1 year ago.

Consciousness confused, inhibited in contact, pale. Ps 150 beats/min, weak filling, A.D 60/40 mm Hg. Hormonal therapy, antibiotic therapy, infusion therapy were started. He was examined by a general practitioner, endocrinologist, intensive care specialist.

USDG of the lower limb arteries was performed (Table 1).

**Table 1.**  
USG data.

Indicators	V max cm/sec	Type of blood flow	% stenosis	Indicators	V max cm/sec	Type of blood flow	% stenosis
On the left				On the right			
OBA	45	mainline	25	OBA	42	mainline	30
GBA	50	mainline	35	GBA	55	mainline	35
PBA	40	mainline	35	PBA	50	mainline	40
PCA	35	mainline	25	PCA	46	mainline	85 ниже подколенной щели
ZBBA	20	mainline - modified	30	ZBBA	15	collateral	50
ZBBA	25	mainline	35	ZBBA	0	occlusion	
MBA				MBA	23	mainline - modified	70

There are sharply enlarged inguinal lymph nodes on the right side, heterogeneous structure, edema.

Swelling of subcutaneous tissue and muscle tissue of the right shin.

At this stage, taking into account all research data and the general extremely severe condition of the patient, amputation of the right lower limb above the knee joint is indicated (for vital indications).

Additionally, the study of oxygen partial pressure in the tissues of the right lower limb was performed: transcutaneous oximetry with assessment of tissue perfusion.

The following data were obtained during this study (Table 2).

**Table 2**  
*TcpO<sub>2</sub> and SpO<sub>2</sub> data of the lower extremities*

Name	Tcp O <sub>2</sub> right	Lying down	b/3 shins	c/3 shins	n/3 shins	The limb is elevated 45°	b/3 shins	c/3 shins	n/3 shins	SpO <sub>2</sub> right	Lying down	The limb is elevated 45°
G.Kh.A.			58	62	9		56	52	7		70	70
	skin's dark		36,0	35,8	35,5		36,0	35,8	35,5			
	Tcp O <sub>2</sub> left	Lying down	b/3 shins	n/3 shins	foot	The limb is elevated 45°	b/3 shins	n/3 shins	foot	SpO <sub>2</sub> left	Lying down	The limb is elevated 45°
			62	60	38		60	60	30		74	72
	skin's dark		36,0	35,8	35,4		36,0	35,8	35,4			

Taking into account the data on partial pressure and oxygen saturation in the tissues of the right lower limb, a decision was made to minimize the height of amputation of the right lower limb, preserving the knee joint. The final volume of the organ-removing operation is determined directly on the operating table. The issue of life support was fully agreed upon with the anesthesiology team.

It is known that in critical ischemia of the lower extremities against the background of irreversible ischemia of the foot and occlusion below the popliteal fissure, the greatest lesions are observed in m. soleus with preservation of collateral blood supply in m. gastrocnemius [1,8]. Based on these practical recommendations, amputation of the right lower limb was performed at the level of the middle/lower third of the leg using the Mitish-Svetukhin-Chupin method [1].

The postoperative period proceeded smoothly. Stay in the intensive care unit for 2 days. The drains were removed on the 5th day. Healing by primary intention. Discharged on the 10th day.

The patient was examined 4 months after the operation: the stump was intact and supporting. He is active and walks on crutches with elbow supports. A course of additional rehabilitation measures followed by prosthetics was prescribed.

The patient was examined 6 months after the operation: the stump was intact and supporting. Moves on a prosthesis with partial support on a stick.

Conclusions: 1. TcpO<sub>2</sub> data and SpO<sub>2</sub> data of tissues of the lower extremities completely correlate with the morphological picture of the viability and arterial blood supply of muscle tissue. 2. Data from oxygenation indicators/oxygen perfusion/ are an important link in diagnosing the condition of soft tissues in the com-

plicated course of diabetic foot syndrome, allowing one to determine treatment tactics. 3. The use of modern non-invasive medical imaging methods makes it possible to optimize the level of organ-removing surgical interventions; reduce tissue and organ loss. 4. Based on a clinical case, it was determined that tissue perfusion indicators (hardware-determined) make it possible to practically implement the principles of organ and tissue preservation in DFS surgery.

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痉挛性脑瘫儿童的临床和免疫学相关性  
**CLINICAL AND IMMUNOLOGICAL CORRELATIONS IN  
CHILDREN WITH SPASTIC CEREBRAL PALSY**

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抽象的。本文介绍了 50 名痉挛型脑瘫儿童的临床和免疫学检查结果。对淋巴细胞免疫表型结果进行比较定量分析发现,重度脑瘫患儿淋巴细胞亚群指标下降(2倍以上),而功能性吞噬细胞活性增加( $p \leq 0.05$ ),具有统计学意义。淋巴细胞亚群水平与运动受限程度之间存在统计学上显著的负相关。在患有严重脑瘫的儿童中,血清和口腔液中的肿瘤坏死因子- $\alpha$  (TNF- $\alpha$ ) 值均显著升高(分别为  $p \leq 0.01$  和  $p < 0.05$ ),并且运动受限的严重程度与血清和口腔液中 TNF- $\alpha$  的水平存在很强的相关性,这使我们能够提出该指标来预测脑瘫痉挛形式的严重程度。

关键词: 脑瘫, 细胞因子 TNF- $\alpha$ , 痉挛性麻痹, GMFCS。

**Abstract.** *The results of a clinical and immunological examination of 50 children with spastic forms of cerebral palsy are presented. A comparative quantitative analysis of the results of immunophenotyping of lymphocytes revealed a statistically significant decrease in the indicators of lymphocyte subpopulations (more than 2 times) with an increase in functional phagocytic activity in children with severe forms of cerebral palsy ( $p \leq 0.05$ ). A statistically significant negative correlation was revealed between the level of lymphocyte subpopulations and the degree of motor limitations. In children with severe forms of cerebral palsy, significantly high values of tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ) were obtained both in the blood serum and in the oral fluid ( $p \leq 0.01$  and  $p < 0.05$ , respectively), as well as a strong correlation dependence of the severity of motor restrictions and the level of TNF- $\alpha$  in the blood serum and in the oral fluid, which allows us to propose this indicator for predicting the severity of spastic forms of cerebral palsy.*

**Keywords:** *cerebral palsy, cytokine TNF- $\alpha$ , spastic paralysis, GMFCS.*



Cerebral palsy (CP) is commonly defined as a group of persistent movement and postural disorders causing activity limitations caused by non-progressive disorders in the brain that occur early in development with lifelong pathophysiological consequences that include dysregulation of innate immunity [1,2,3]. This definition remains widely used, but gaps remain due to heterogeneity of presentation, interpretation of the term “non-progressive disorders” and the age at which cerebral palsy may develop. Inflammation has been described in the pathogenesis of most perinatal brain injuries, which contributes to the risk of cerebral palsy, including neonatal stroke, preterm birth, birth asphyxia and infection [4,5,6,7]. Inflammation in cerebral palsy may involve changes in cytokine status [1]; altered immune response [2]; adaptive immune changes, including the distribution and function of T and B cells [3], as well as other genetic and non-genetic changes in signaling pathways [8]. Inflammation following perinatal brain injury is generally reported to vary over time, between the acute and chronic phases of injury [9]. Systematic reviews of the clinical literature now support an association between higher levels of circulating proinflammatory mediators and the diagnosis of cerebral palsy, particularly in the setting of prematurity [1]. However, the duration and extent of this inflammation, as well as the consequences for children with cerebral palsy, remain unclear.

Scientific research in recent years has proven that cerebral palsy can be considered as a longitudinal pathological process that actively occurs throughout the life of the sick child [10,11]. Lin et al. when examining children with cerebral palsy of school age, they demonstrated the possibility of long-term complications on the developing brain of premature children with cerebral palsy of proinflammatory cytokines, prostaglandins and lipopolysaccharides [12]. Altered cytokine responses in children with CP demonstrate a persistent inflammatory state that may contribute to ongoing sequelae. This study supports the hypothesis that the inflammatory response changes years after brain injury in children with cerebral palsy [13].

Currently, extensive study of immune regulation disorders, variability in the enzymatic activity of immunocompetent cells, and neurobiochemical markers in various CNS lesions, including cerebral palsy, continues [14,15,16]. Among the markers of neurodestructive and reparative processes that are currently being actively studied in hypoxic-ischemic damage to the central nervous system, special attention is paid to the cytokine regulatory network. One of the main cytokines in the early response to neuronal damage is tumor necrosis factor alpha (TNF- $\alpha$ ) [17]. Increased expression of TNF- $\alpha$  causes neutrophil infiltration, which increases endothelial cell permeability and activates matrix metalloproteinases, which damage the blood-brain barrier, leading to swelling and degeneration of neurons and glial cells, thereby exacerbating brain damage [18]. The inflammatory response

of these cytokines persists even in school-aged children with neonatal encephalopathy, demonstrating adverse neurodevelopmental outcome, and continues after birth, leading to the “persistent inflammation hypothesis,” which posits that prenatal, perinatal, and/or neonatal proinflammatory stimuli induce inflammatory responses that contribute to ongoing cytokine dysregulation.

**Goal of the work.** To assess the relationship between the severity of motor disorders in children with spastic cerebral palsy and certain indicators of immune status.

**Research material.** As part of the research work, 50 children aged 2 to 5 years ( $3.9 \pm 1.2$  years) with spastic forms of cerebral palsy were examined: with unilateral (hemiparesis) - 24 people. (48%), bilateral (paraparesis, diplegia, tetraparesis) paralysis – 26 people. (52%). Depending on the level of motor development, the subjects were divided into 5 groups: Group 1 – 7 (14%) children, level I according to GMFCS (walks without assistance and restrictions); Group 2 – 13 (26%) children, level II according to GMFCS (walks without assistance, without leaving the room); Group 3 – 11 (22%) children, GMFCS level III (walks with the help of assistive devices); Group 4 – 10 (20%) children, level IV according to GMFCS (moves in a wheelchair, limited independent movement); Group 5 – 8 (18%) children, level V according to GMFCS (moves very limited). The comparison group consisted of 25 healthy children matched by gender and age. Written informed consent was obtained from all parents of children included in the study before inclusion in the study.

**Research methods.** All children underwent clinical, neurological and instrumental examinations, including MRI of the brain. Neurological status was assessed using a generally established method using special scales (Modified Ashworth Scale for Grading Spasticity, 6-point assessment of muscle strength (according to Mcpeak L., 1996; Weiss M., 1986)). The severity of motor dysfunction was assessed using the Gross Motor Function Classification System (GMFCS, (Gray et al., 2010)).

The study of immune status was carried out in accordance with the developed panel of standard tests. Phenotyping of lymphocyte populations and subpopulations was carried out by flow cytometry; phagocytic and redox activity of neutrophils was determined in the phagocytosis test and the nitroblue tetrazolium test (NBT test). The concentration of TNF- $\alpha$  in peripheral blood serum and oral fluid was determined by enzyme-linked immunosorbent assay (ELISA) using a set of reagents from Vector-Best LLC (Russia, Novosibirsk).

Statistical processing of the results was carried out using the spreadsheet editor MS Excel 2016 using standard statistical procedures. P values  $<0.05$  were considered statistically significant.

**Results and discussion.** Assessment of the degree of spasticity (according to the modified Ashworth spasticity scale) revealed a severe degree of neurological

deficit in groups of children with double hemiplegia (63% of patients in this group,  $p = 0.006$ ) and spastic diplegia (56% of patients in this group,  $p \leq 0.05$ ). In 83% of those examined with a hemiparetic form, a mild degree predominated. Children suffering from moderate double hemiplegia had a significant advantage over children in other groups ( $p = 0.003$ ).

According to the data obtained, in children with unilateral spastic cerebral palsy, GMFCS levels I and II were determined in 91% of cases, and the ability to walk independently and to walk with limitations was preserved. In contrast to patients with unilateral spastic cerebral palsy, patients with bilateral spastic cerebral palsy were able to move independently in only 22% of cases. GMFCS level III was detected in 27% of patients with bilateral spastic cerebral palsy. Statistically significantly more often ( $p \leq 0.05$ ) in those examined with bilateral spastic variants of cerebral palsy, limitations in the ability to move independently were observed – GMFCS level IV (27%). It is important to note that the level of GMFCS does not depend on the clinical type of cerebral palsy, since bilateral and unilateral spastic forms imply a certain degree of reduction in the level of functional motor independence. In the case of bilateral spastic cerebral palsy, statistically significant inverse correlations of muscle strength indicators and muscle tone indicators with GMFCS levels were revealed ( $R = -0.37$  and  $R = -0.52$ , respectively;  $p \leq 0.05$ ). Consequently, the variability of movement disorders in bilateral spastic variants of cerebral palsy determines a decrease in their ability to move and limited functionality, and the identified statistically significant correlations allow us to classify spastic paresis as the dominant movement disorder associated with a decrease in the functionality of patients in the main group.

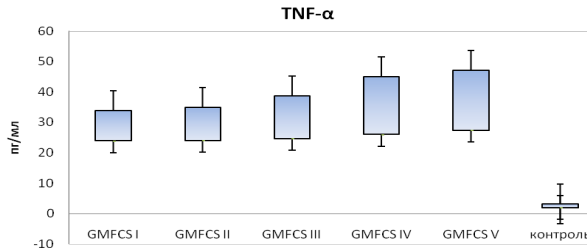
Children with cerebral palsy underwent an immunological study to determine the main classes of lymphocytes CD3+, CD4+, CD8+, CD3+/CD4+, CD16+, CD19+, CD20+. Immunophenotyping of blood lymphocytes revealed a pronounced deficiency of the main populations in general, and of the subpopulation composition in children of the main group. A comparative quantitative analysis of the expression of CD3+CD4+ lymphocytes revealed a significant decrease in indicators by more than 2 times in children with severe forms of cerebral palsy (GMFCS IV and GMFCS V) compared to the control group ( $p \leq 0.05$ ). A negative correlation was established between the level of lymphocyte subpopulations and the degree of motor limitations (GMFCS II ( $R = -0.62$ ), GMFCS III ( $R = -0.69$ ), GMFCS IV ( $R = -0.78$ ) and GMFCS V ( $R = -0.67$ ).

The study of macrophage activity revealed significant activation of the intracellular mechanism of neutrophils. These cells express a wide range of membrane receptors that allow them to respond appropriately to microenvironmental stimuli that regulate neutrophil functions, such as activation, migration, generation of reactive oxygen species, formation of neutrophil extracellular traps and mediators,

secretion, among others. The main effector function of neutrophils is the inflammatory process. The activity of oxygen-dependent mechanisms in the spontaneous NBT test in all children with spastic forms of cerebral palsy was more than 2 times higher than in children in the control group ( $27.7\pm 19.9\%$  and  $11.0\pm 12.5\%$ , respectively;  $p < 0.05$ ). A strong positive correlation was established between the severity of motor limitations and the activity of oxygen-dependent mechanisms ( $R=0.71$ ). Taking into account that the NBT test characterizes the activity of intracellular oxygen-dependent phagocyte systems, high NBT-spont rates were obtained. may indicate the presence in children with cerebral palsy (GMFCS IV and GMFCS V, to a greater extent) of factors contributing to the activation of neutrophils. The source of antigenic irritation of blood granulocytes can be pathological changes, such as dysfunction of the blood-brain barrier and neuroinflammation, supported by activated microglia.

Analyzing the results obtained on the content of pro-inflammatory cytokines in the examined children, we can say the following. A persistent abnormal cytokine response was revealed in young children with spastic forms of cerebral palsy. The level of  $TNF-\alpha$  in the blood serum of children in the main group was  $8.17\pm 6.99$  pg/ml and was significantly higher than in children of the comparison group ( $0.74\pm 0.72$  pg/ml;  $p\leq 0.05$ ). An interesting fact was the connection between high  $TNF-\alpha$  values and low levels of gross motor functions ( $p\leq 0.01$ ). The study revealed a strong correlation between the severity of motor limitations and the level of  $TNF-\alpha$  in the blood serum: GMFCS II ( $R = 0.67$ ), GMFCS III ( $R = 0.73$ ), GMFCS IV ( $R = 0.92$ ) and GMFCS V ( $R = 0.70$ ), confirming the hypothesis that circulating levels of  $TNF-\alpha$  may reflect the activity of neuroimmune pathogenetic processes that are clinically associated with the severity of motor dysfunction in spastic forms of cerebral palsy in children 2-5 years of age.

A study of the level of  $TNF-\alpha$  in oral fluid showed significantly high values in children of the main group compared to the control group ( $27.54\pm 17.44$  pg/ml and  $1.99\pm 1.11$  pg/ml, respectively,  $p\leq 0.01$ ). The identified imbalance of Th1-type cytokines correlates with the severity of motor limitations:  $TNF-\alpha$  levels are significantly correlated with GMFCS in patients with spastic tetraparesis ( $R = 0.81$ ) and spastic diplegia ( $R = 0.77$ ). (Picture 1).



**Figure 1.** Comparative analysis of  $TNF-\alpha$  concentration in oral fluid in children with spastic forms of cerebral palsy depending on the level of GMFCS

Note:  $p \leq 0.01$ ; compared to the control group

The detected level of pro-inflammatory cytokines reflects a high significance in the local inflammatory response and an important role in the initiation of the cytokine cascade. The constant activation and accumulation of proinflammatory cytokines prevents the restoration of central nervous system function after injury, thereby contributing to the development of severe forms of cerebral palsy. These pathological changes adversely affect oligodendrocyte maturation, limiting neuronal regeneration and impairing synapse formation.

The increased levels of circulating  $TNF-\alpha$  found in our study in children with spastic forms of cerebral palsy suggest that the inflammatory process persists after birth into early childhood. A positive correlation between the level of GMFCS and the concentration of  $TNF-\alpha$  indicates the course of neuroimmune processes in the body of children with spastic forms of cerebral palsy. The results obtained can be used as potential biomarkers to predict the abnormal outcome of CNS injuries in children using oral cytokine monitoring, which provides non-invasive and reliable information for the development of therapeutic strategies for the early treatment of neonatal encephalopathies and cerebral palsy.

**Conclusion:** Analyzing the data obtained, it can be assumed that in children with spastic forms of the early residual stage of cerebral palsy, an immunopathological process occurs that correlates with the level of motor restrictions (the severity of cerebral palsy) in the patient. It is possible that the neuroimmune process, initiated in utero or intrapartum, maintains active inflammation (damage) of nerve fibers, which prevents effective therapy and rehabilitation of children with cerebral palsy. Of course, the mechanisms of pathogenesis of spastic forms of cerebral palsy and the diagnosis of pathophysiological processes require further in-depth study. Adequate diagnosis and early comprehensive intervention from the first months of life of a child with neonatal encephalopathy will help correct existing

developmental deviations, reduce the risk of developing severe forms of spastic paralysis, prevent the occurrence of secondary disorders, and achieve the highest possible level of development of gross motor functions and independence for each child.

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COVID-19 急性期一年后患者中 COVID-19 后综合征表现的动态变化  
**DYNAMICS OF POST-COVID-19 SYNDROME MANIFESTATIONS  
IN PATIENTS, ONE YEAR AFTER THE ACUTE PHASE OF  
COVID-19**

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注解。介绍。对于在 COVID-19 急性期后出现呼吸道症状和残留影像学变化持续超过 3 个月的患者，提出了“Covid 后间质性肺病”这一术语。在动态观察阶段，患者在新冠疫情后的变化仍然具有相关性。

目标。COVID-19 后的长期后果分析。

材料与方法。对 53 例 COVID-19 患者的动态观察，使用 VAS、mMRC、HADS 量表评估临床表现

结果。男性 38%，女性 62%，平均年龄 62 岁 [56–66]，体重指数 (BMI)  $30 \pm 7$  kg/m<sup>2</sup>。26.5% 的病例接种了 COVID-19 疫苗。新型冠状病毒感染 (NCVI) 的严重程度分布为中度 (54%)、重度 (28.6%)、极重度 (14.3%) 和轻度 (3.2%)。在纳入研究时，NKVI 的主要表现是 100% 的病例出现呼吸急促 (mMRC 3 – 45.5%)，88.6% 的病例出现咳嗽 (VAS  $6 \pm 3$ )，82.9% 的病例出现肌无力。%，认知障碍 – 85.7%，关节痛 – 25.7%。6 个月后，观察到临床表现的动态变化：呼吸短促 – 96.4% (mMRC 2 – 48.3%)，咳嗽 – 60.7% (VAS-3)，肌肉无力 – 50.0%，认知障碍 – 85.7%，关节痛 – 53.6%。1 年后，症状如下：87.1% 出现呼吸急促 (mMRC2-45.2%)，咳嗽 – 45.2% (VAS-2)，肌肉无力 – 32.3%，认知障碍 – 74.2%，关节痛 – 61.3%。

结论。一年后对新冠肺炎后综合征临床表现的评估显示了其相关性，特别是对于合并症患者。对于不同严重程度的 COVID-19 患者，各种康复计划方法脱颖而出，这些方法在一年后仍然适用。

关键词：COVID-19、新冠肺炎后综合症。



**Annotation. Introduction.** For patients with respiratory symptoms and residual radiographic changes that persist for more than 3 months after the acute phase of COVID-19, the term “post-Covid interstitial lung disease” has been proposed. At the stage of dynamic observation, post-Covid changes in patients remain relevant.

**Target.** Analysis of long-term consequences after COVID-19.

**Material and methods.** Dynamic observation of 53 patients who had COVID-19, assessing clinical manifestations using VAS, mMRC, HADS scales

**Results.** Men 38%, women 62%, average age 62 years [56-66], body mass index (BMI)  $30 \pm 7$  kg/m<sup>2</sup>. Vaccination against COVID-19 was carried out in 26.5% of cases. The severity of the new coronavirus infection (NCVI) was distributed as moderate severity in 54%, severe in 28.6%, extremely severe in 14.3% and mild in 3.2%. The main manifestations of NKVI at the time of inclusion in the study were noted in the form of shortness of breath in 100% of cases (mMRC 3 - 45.5%), cough in 88.6% (VAS 6±3), muscle weakness in 82.9%, cognitive impairment - 85.7% and arthralgia - 25.7%. After 6 months, the dynamics of clinical manifestations were noted: shortness of breath - in 96.4% (mMRC 2 - 48.3%), cough - in 60.7% (VAS-3), muscle weakness - 50.0%, cognitive impairment - 85.7%, arthralgia - 53.6%. After 1 year, symptoms were presented as follows: shortness of breath in 87.1% (mMRC2-45.2%), cough - 45.2% (VAS-2), muscle weakness - 32.3%, cognitive impairment - 74.2 %, arthralgia - 61.3%.

**Conclusion.** Evaluation of clinical manifestations of post-COVID syndrome after a year shows its relevance, especially in comorbid patients. In patients with various degrees of severity of COVID-19, various methods of rehabilitation programs come to the fore, which remain relevant after a year.

**Keywords:** COVID-19, post-COVID syndrome.

**Introduction.** For patients with respiratory symptoms and residual radiographic changes that persist for more than 3 months after the acute phase of COVID-19, the term “post-COVID interstitial lung disease” has been proposed. At the stage of dynamic observation, post-COVID changes in patients remain relevant. Respiratory manifestations of post-COVID syndrome are the most frequently recorded consequences of COVID-19 [1]. Half of the patients experience persistence of symptoms after discharge from hospital [2]. There is no final clarity for how long post-COVID interstitial changes in the lungs persist and how reversible they are [2]. During dynamic observation in patients who had COVID-19, X-rays revealed traction bronchiectasis and other changes in the lungs, which persisted after 6 and 12 months of observation [3]. In this regard, treatment and rehabilitation of the long-term consequences of COVID-19 come to the fore. This determined the goal of the work in the form of an analysis of long-term consequences after suffering from COVID-19.

### **Materials and methods.**

A dynamic observation of 53 patients who had suffered COVID-19 was carried out, with clinical manifestations assessed using the VAS, mMRC, HADS scales. Among them are 38% men, 62% women, and average age 62 years [56-66], body mass index (BMI)  $30 \pm 7$  kg/m<sup>2</sup>. Vaccination against COVID-19 was carried out in 26.5% of cases.

**Results.** Hospitalization to the infectious diseases hospital occurred on average on the 6th (4-10) day of illness. The bed-day in the infectious diseases hospital was 24 (21-42) days. In 30.4%, patients were admitted to the ICU. The severity of the new coronavirus infection (NCVI) was distributed as moderate severity in 54%, severe in 28.6%, extremely severe in 14.3% and mild in 3.2%. Respiratory support regimens were presented in the form of oxygen therapy through nasal canulas in 70%, NIV - 28%. Comorbid pathology prevailed as ischemic heart disease in 20%, arterial hypertension - 94.9%, diabetes mellitus - 26.7%, COPD/bronchial asthma - 11.1%, thyroid disease - in 31.1% of cases.

The main manifestations of NKVI at the time of inclusion in the study were noted in the form of shortness of breath in 100% of cases (mMRC 3 - 45.5%), cough in 88.6% (VAS  $6 \pm 3$ ), muscle weakness in 82.9%, cognitive impairment - 85.7% and arthralgia - 25.7%. Cough frequency increased in sicker patients, who were in an infectious diseases hospital on auxiliary ventilation modes (NIV, IVL). Dry, paroxysmal cough was more common. Also, frequent complaints among patients were muscle weakness (all patients had severe and extreme severity), loss of muscle mass and, as a result, limitation of daily activity. These problems were especially relevant for patients who were in the acute period of COVID-19 in the ICU. A high percentage of cognitive impairment was observed in patients after the acute period of COVID-19. Anxiety and depression were noted in patients with severe and extremely severe disease in half of the cases.

After 6 months, the dynamics of clinical manifestations were noted: shortness of breath - in 96.4% (mMRC 2 - 48.3%), cough - in 60.7% (VAS-3), muscle weakness - 50.0%, cognitive impairment - 85.7%, arthralgia - 53.6%. After 1 year, symptoms were presented as follows: shortness of breath in 87.1% (mMRC2-45.2%), cough - 45.2% (VAS-2), muscle weakness - 32.3%, cognitive impairment - 74.2%, arthralgia - 61.3%.

According to the HADS scale, subclinical anxiety was initially noted in patients with severe COVID-19 symptoms (me - 10), while subclinical depression was observed in patients with moderate COVID-19 symptoms (me - 9). After 6 months, anxiety and depression scores did not exceed normal levels. However, after one year, subclinical anxiety (mean score - 8) was observed in patients with moderate to severe COVID-19 symptoms, although anxiety scores remained within normal range.

Noteworthy is the duration of persistence of symptoms, primarily shortness of breath and/or cough.

**Table 1.**

*Dynamics of indicators of oxygenation and load tolerance tests in patients*

Parameters in dynamics	Mild course of NKVI	Moderate NKVI	Severe course	Extremely severe course	R
SpO2 primary, % Me [Q1-Q3]	98 [95-99]	94[89 - 98]	91[88 - 92]	86[93 - 88]	p = 0.009
SpO2 after 6 months % Me [Q1-Q3]	98 [96-99]	98[98 - 98]	96[95 - 98]	94[90 - 96]	p = 0.004
SpO2 after a year % Me [Q1-Q3]	98 [98-98]	98 [98-98]	98 [95-98]	95 [93-97]	p = 0.085
T6X primary, m Me [Q1-Q3]	360 [360-360]	200[120-300]	75[0-138]	185[50-300]	p = 0.197
T6X after 6 months, m Me [Q1-Q3]	370 [340-400]	350 [300-400]	400 [332-400]	380 [340-420]	p = 0.411
T6X after 1 year, m Me [Q1-Q3]	350 [325-375]	380[300-400]	400[350-400]	330[225-360]	p = 0.495

Note: T6X – 6-minute walk test, p – significance of differences between extremely severe and moderate cases of NKVI

Over time, a year after the acute phase of NKVI, tolerance to physical activity increases, especially in patients with severe NKVI, and the percentage of desaturation decreases. Table 1.

**Conclusion.** An assessment of the clinical manifestations of post-COVID syndrome after a year shows the continued relevance of the persistence of symptoms, especially in comorbid patients. In patients with varying degrees of severity of COVID-19, various methods of recovery programs come to the fore, retaining their relevance a year after the acute phase of the disease. In patients with severe NKVI, according to the results of clinical manifestations, after six months, the relevance of both physical and cognitive rehabilitation increases. In patients with mild NKVI, cognitive rehabilitation subsequently comes to the fore. In this group, despite the high percentage of increase in T6X tolerance, it is important to maintain a decrease in tolerance to physical activity. During long-term observation, patients with severe COVID-19 and comorbid pathology show positive dynamics in the form of a decrease in scores on the mMRC dyspnea scale and VAS, but the persistence of the course of post-COVID syndrome is noteworthy. Post-COVID manifestations (shortness of breath, cognitive impairment), which remain relevant at the stage of one-year observation, and the appearance of new clinical symptoms

determine the need for further observation of these patients with clarification of indications for subsequent adjusted targeted rehabilitation and drug therapy.

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中毒性视神经病背景下视神经萎缩的眼部血管膜内皮血管生长因子 (VEGF) 水平的变化

**CHANGES IN THE LEVEL OF ENDOTHELIAL VASCULAR GROWTH FACTOR (VEGF) IN THE VASCULAR MEMBRANE OF THE EYE WITH THE DEVELOPMENT OF OPTIC NERVE ATROPHY AGAINST THE BACKGROUND OF TOXIC OPTICONEUROPATHY**

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注解。 视神经病理学在眼部疾病中占有特殊地位，其特点是主诉范围广泛且症状多变。 视神经萎缩的发病机制基于视网膜神经节细胞或其轴突的损伤，目前的诊断基于临床数据[1]。 治疗措施的有效性取决于早期治疗，而如果不及时诊断视力萎缩，早期治疗是不可能的。 因此，诊断此类疾病的早期方法问题在医学发展的现阶段仍然具有相关性。

本研究的目的是基于形态学数据，研究中毒性视神经病变背景下视神经萎缩不同发展时期眼部脉络膜血管内皮生长因子 (VEGF) 水平的动态变化。

材料和方法：在工作过程中，在建立视神经萎缩模型后，对40只实验大鼠的眼睛进行了研究。 将所有实验动物分为5组：第1组-对照组，第2组-实验动物，在建立视神经萎缩模型1周后摘除眼睛，第3组-实验动物，在3周后摘除眼睛，第3组-实验动物。 第4组——6周后摘除眼睛的实验动物，第5组——创建视神经萎缩模型后9周摘除眼睛的实验动物。 免疫荧光分析：对眼球的固定横切面进行染色。 实验动物的脉络膜用 VEGF 小鼠单克隆受体抗体染色。 使用统计计算环境 R 4.2.2 (R 统计计算基金会, 维也纳, 奥地利) 对所获得的数据进行统计分析和可视化。

研究结果：在比较分析过程中，我们发现第5组的VEGF水平在统计学上显着较高，平均为4.08 (95% CI: 1.97; 8.45,  $p < 0.001$ )、3.11 (95% CI: 1.62; 5.95,  $p$  与第1组、第2组和第4组相比，分别高出  $< 0.001$ ) 和 2.9 (95% CI: 1.51; 5.59,  $p < 0.001$ ) 倍。

结论: 脉络膜VEGF受体抗体水平升高提示血脑屏障发生病变, 导致神经上皮细胞损伤和病理性新生血管形成。

关键词: 中毒性视神经病变、视神经萎缩、免疫荧光分析、血管内皮生长因子(VEGF)。

**Annotation.** *Pathology of the optic nerve occupies a special niche among eye diseases and is characterized by a wide range of complaints and variability of symptoms. The pathogenesis of optic atrophy is based on damage to retinal ganglion cells or their axons, and currently the diagnosis is based on clinical data [1]. The effectiveness of therapeutic measures depends on early therapy, which in turn is impossible without timely diagnosis of visual atrophy. Thus, the question of early methods for diagnosing this group of diseases remains relevant at the present stage of development of medicine.*

*The purpose of this study was to study the dynamic changes in the level of vascular endothelial growth factor (VEGF) in the choroid of the eye at different periods of development of optic nerve atrophy against the background of toxic optic neuropathy based on morphological data.*

*Materials and methods: During the work, 40 eyes of experimental rats were studied after creating a model of optic nerve atrophy. All experimental animals were divided into 5 groups: group 1 - control, group 2 - experimental animals, whose eyes were enucleated 1 week after creating a model of optic nerve atrophy, group 3 - experimental animals, whose eyes were enucleated after 3 weeks, group 4 - experimental animals whose eyes were enucleated after 6 weeks, and group 5 - experimental animals whose eyes were enucleated 9 weeks after creating a model of optic nerve atrophy. Immunofluorescence analysis: staining was performed on fixed transverse sections of the eyeball. The choroid of experimental animals was stained with antibodies to VEGF Mouse Monoclonal receptors. Statistical analysis and visualization of the obtained data were carried out using the statistical computing environment R 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria).*

*Study results: During the comparative analysis, we found that the level of VEGF was statistically significantly higher in group 5 on average 4.08 (95% CI: 1.97; 8.45,  $p < 0.001$ ), 3.11 (95 % CI: 1.62; 5.95,  $p < 0.001$ ) and 2.9 (95% CI: 1.51; 5.59,  $p < 0.001$ ) times higher compared to group 1, 2 and 4, respectively.*

*Conclusions: an increase in the level of antibodies to VEGF receptors in the choroid indicates pathology of the blood-brain barrier, which leads to damage to the cells of neuroepithelium and pathological neovascularization.*

**Keywords:** *toxic optic neuropathy, optic nerve atrophy, immunofluorescence analysis, vascular endothelial growth factor (VEGF).*

**General information.** *Pathology of the optic nerve occupies a special niche among eye diseases and is characterized by a wide range of complaints and var-*

iability of symptoms. The pathogenesis of optic atrophy is based on damage to retinal ganglion cells or their axons, and currently the diagnosis is based on clinical data [1]. Modern ophthalmology is characterized by the rapid growth of constantly improving high-tech diagnostic and treatment methods. Despite extensive research into toxin-induced vision pathology in humans, in which tissue-specific damage occurs, the histopathological changes in ocular structures other than the optic nerve and retina remain unclear.

**Morphofunctional features of the choroid of the eye.** The vascular membrane of the eye is composed of three main parts: the iris, the ciliary body, and the choroid [2]. Angiogenesis is a multistep, tightly regulated process controlled by a dynamic balance of positive and negative factors. It is believed that VEGF-A is the main type responsible for angiogenesis, interacting with VEGF receptors (VEGFR) 1 and 2 [3]. VEGF stands for vascular endothelial growth factor. Increased regulation of VEGF leads to disruption of tight junctions in endothelial cells, which in turn affects the blood-brain barrier and vascular permeability. VEGF induces the production of pro-inflammatory and pro-angiogenic mediators by macrophages and microglia in the retina and choroid, making it a marker of pathological neovascularization [4]. VEGF is considered the main mediator of pathology in both wet age-related macular degeneration and diabetic retinopathy, and is the target of modern therapeutic interventions [5].

**Purpose of the study:** to study of dynamic changes in the level of vascular endothelial growth factor (VEGF) in the choroid of the eye, different periods of development of optic nerve atrophy against the background of toxic optic neuropathy based on morphological data.

**Materials and methods.** During the work, 40 eyes of experimental animals were examined. Sexually mature Wistar rats ( $n=20$ , weight 250-300 g, age 14-16 weeks). Rats were housed singly per cage under standard laboratory conditions on a 12-hour day/night schedule, with free access to food and water. All manipulations were carried out in accordance with the order of the Ministry of Health and Social Development No. 708n dated 08.23.2010 "On approval of the rules of laboratory practice" and with the permission of the Local Ethics Committee of the Kazan State Medical University (minutes of meeting No. 5 of 05.27.2014, minutes of meeting No. 2 of 02.20.2018).

The method for creating a toxic model of optic nerve atrophy is carried out as follows: within 24 hours before the administration of methanol, Aminophylline is first administered orally to rats based on the weight of the experimental animal (average weight 500-700 g) at a concentration of 10 mcg/kg 3 times a day, the last dose of Aminophylline was carried out 8 hours before the injection of methanol solution. Next, a 92% methanol solution diluted with a 0.9% sodium chloride solution in a 1:1 ratio is injected into the retrobulbar space of the rat. After the injection

of methanol, over the next 24 hours, Aminophylline is administered orally based on the weight of the experimental animal at a concentration of 10 mcg/kg 3 times a day, the first injection is carried out 2 hours after the injection. This model, due to the toxic effect of methanol, allows for optic nerve atrophy [6].

During the work, 40 eyes of experimental animals (rats) were studied after creating a model of optic nerve atrophy. All experimental animals were divided into 5 groups: group 1 – control, group 2 – experimental animals whose eyes were enucleated after 1 week after creating a model of optic nerve atrophy, group 3 - experimental animals whose eyes were enucleated 3 weeks after creating a model of optic nerve atrophy, group 4 - experimental animals whose eyes were enucleated 6 weeks after creating a model of optic nerve atrophy, and 5 group - experimental animals whose eyes were enucleated 9 weeks after creating a model of optic nerve atrophy. This temporal distribution made it possible to consider morphological and immune and histological changes in the structures of the eye at different stages of the development of optic nerve atrophy.

Experimental animals were anesthetized with chloral hydrate (80 mg/ml, 0.4 ml intraperitoneally), and a section of the studied ocular structure (choroid) was removed, which was then postfixed in 4% paraformaldehyde. Classical schistological studies were carried out on fixed transverse sections of rat eyes. Staining was done with Hematoxylin and Eosin.

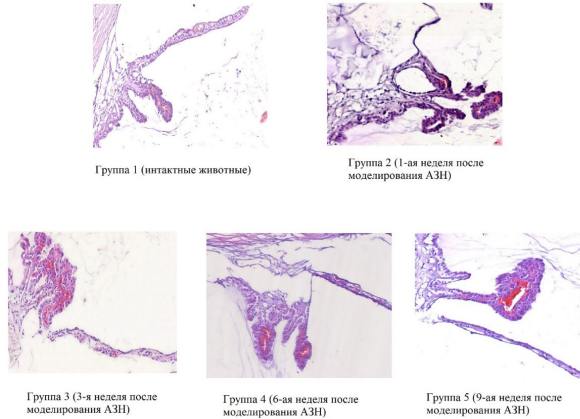
**Immunofluorescence analysis.** Immunofluorescence staining was performed on fixed transverse sections of the eyeball. The choroid of the eye was stained with antibodies to VEGF receptors Mouse Monoclonal Antibody. Analysis of stained sections was carried out using a confocal scanning microscope LSM 510 META (Carl Zeiss, Germany). Digital images of eye sections were analyzed using ImageJ (NIH). When counting the number of immunopositive cells, the presence of DA-PI-stained nuclei in the cells was taken into account.

**Statistical analysis:** Statistical analysis and visualization of the obtained data were carried out using the statistical computing environment R 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics for quantitative indicators are presented as medians (1st and 3rd quartiles). To compare groups on quantitative variables with positively (left-sided) skewed sample distributions, linear models were used with the dependent variable included after log transformation, and in such cases, estimates of the ratio of group medians with corresponding 95% confidence intervals (95% CI) were used as effect sizes. To compare quantitative variables without positive skewness of sample distributions, the Kruskal-Wallis test was used, followed by Dunn's test as a post hoc method for pairwise comparisons. Differences were considered statistically significant at  $p < 0.05$ .

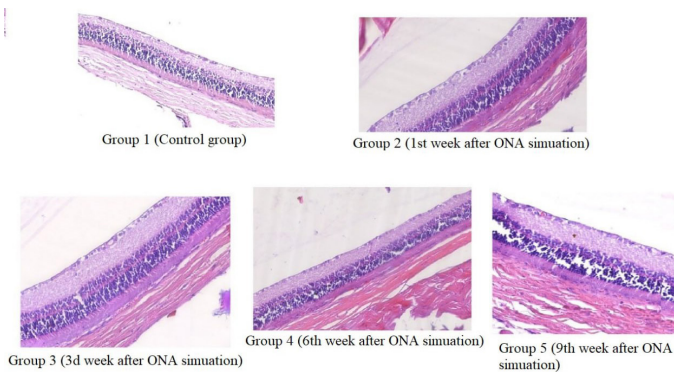
**Research results:** When studying the iris materials when stained with hematoxylin and eosin, no gross morphological changes were revealed. When studying



the materials of the ciliary body, the appearance of vessels was discovered in the inner layer of the ciliary body in the fourth and fifth groups of experimental animals, that is, changes are characteristic from the 6th week after modeling ADN (Figure 1). When studying histological sections of the choroid of experimental animals, the appearance of new vessels in the area of the retina in the fifth group was revealed, that is, at the later stages of the development of atrophic processes in the optic nerve fibers (Figure 2).

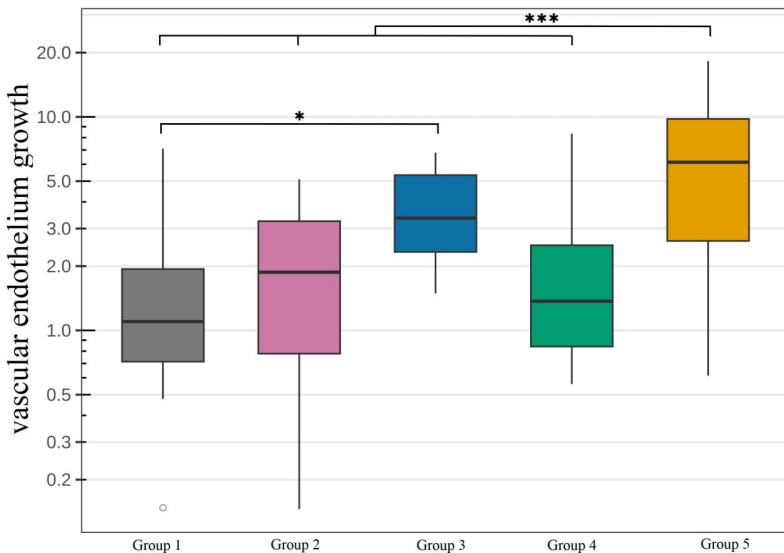


**Figure 1.** Cryostat sections of the anterior part of the choroid (iris and ciliary body) of the eyes of experimental animals (Wistar rats), stained with hematoxylin and eosin. Magnification X40.

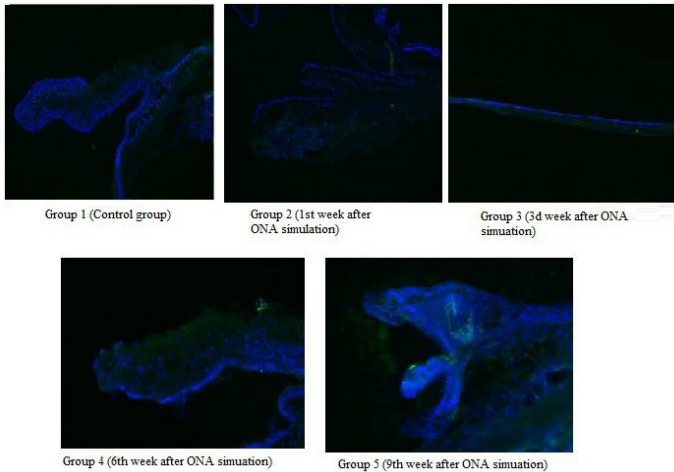


**Figure 2.** Cryostat sections of the posterior part of the choroid (choroid) and retina of the eye of experimental animals (Wistar rats), stained with hematoxylin and eosin. Magnification X40.

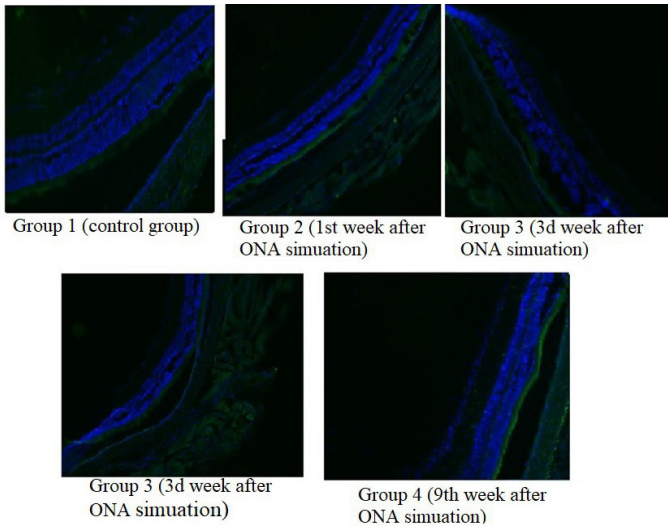
The median level of vascular endothelial growth factor (VEGF) in group 1 was 1.1 (0.71–1.94), in group 2 – 1.87 (0.78–3.25), in group 3 – 3.43 (2.33–5.34), in group 4 – 1.37 (0.84–2.51) and in group 5 – 6.14 (2.63–9.79). During the comparative analysis, we found that the level of VEGF was statistically significantly higher in group 5 on average 4.08 (95% CI: 1.97; 8.45,  $p < 0.001$ ), 3.11 (95% CI: 1.62; 5.95,  $p < 0.001$ ) and 2.9 (95% CI: 1.51; 5.59,  $p < 0.001$ ) times higher compared to groups 1, 2 and 4, respectively. In group 3 compared to group 1, the VEGF level was 2.99 (95% CI: 1.16; 7.72,  $p = 0.015$ ) times higher. When comparing group 3 and group 2, there was a trend toward differences in VEGF levels ( $p = 0.086$ ). When comparing the level of this marker between groups 2 and 1, groups 5 and 3, no statistically significant differences were found ( $p = 0.837$  and  $0.865$ , respectively), and no statistically significant differences were found when comparing the level of VEGF in group 4 compared with groups 1, 2 and 3 ( $p = 0.701$ ,  $0.999$  and  $0.143$ , respectively) (Figure 3).



**Figure 3.** Vascular endothelial growth factor (VEGF) levels in experimental groups. \*\*\* –  $p < 0.001$ , \*\* –  $p < 0.01$ , \* –  $p < 0.05$ .



**Figure 4.** Analysis of changes in the level of antibodies to VEGF in the anterior part of the choroid (ciliary body, iris) based on immunofluorescence examination of the cornea. Sagittal section of the eyes, stained with antibodies to the VEGF receptor (green light). Cell nuclei are stained with DAPI (blue light).



**Figure 5.** Analysis of changes in the level of antibodies to VEGF in the posterior part of the choroid (choroid) based on immunofluorescence examination of the cornea. Sagittal section of the eyes, stained with antibodies to the VEGF receptor (green light). Cell nuclei are stained with DAPI (blue light).

**The discussion of the results.** Some problems of medicine at the present stage of medical development still remain not only scientific, but also social. Optic nerve atrophy is a consequence of a wide variety of pathological processes. The study of structures not directly connected to the optic nerve fibers at the morphological level is relevant for the early diagnosis of optic nerve atrophy. The VEGF factor can influence vascular permeability and induce the production of pro-inflammatory and pro-angiogenic mediators in the retina and choroid by macrophages and microglia, that is, it is a marker of neovascularization. According to the study, a statistically significant increase in the level of antibodies to VEGF receptors was found by the 9th week of development of optic nerve atrophy, which indicates morphological changes in the structure of the choroid and activation of pathological processes of neovascularization. The secretion of VEGF factor is regulated by retinal L channels, which play an important role in the initiation of choroidal neovascularization [7].

**Conclusions:** The appearance of antibodies to the VEGF factor receptor indicates pathological angiogenesis in the choroid of the eye. Thus, the use of antibodies to VEGF in the choroid of the eye can serve as an additional morphological (immunohistochemical) marker of toxic damage to optic nerve fibers.

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血浆佐剂治疗真菌性角膜炎模型角膜炎的实验  
**EXPERIMENTAL USE OF PLASMA ADJUVANTS IN THE  
TREATMENT OF KERATITIS ON A MODEL OF FUNGAL  
KERATITIS**

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抽象的。 工作目的: 通过实验研究和比较血浆佐剂对感染念珠菌属真菌的真菌性角膜炎模型的伤口愈合作用。

材料和方法: 用18只苏联龙猫品种的兔子(18只眼)建立了真菌性角膜炎模型。在实验性使用兔血浆治疗真菌性角膜炎后,对8只兔子(8只眼)的角膜进行了照片记录,并在富含血小板的兔血浆后对8只兔子(8只眼)进行了角膜照片记录。为了防止继发感染的发生,整个实验期间所有兔子均滴注0.3%妥布霉素溶液,1滴,每天4次。两只兔子(2只眼睛)作为对照;受感染的眼睛不予治疗。连续21天每天监测动物。在实验性使用血浆后第2、3、5、7、14和21天,记录角膜的宏观变化。

结果: 根据所用血浆的类型确定了真菌性角膜炎修复过程的特征。富含血小板的兔血浆导致水肿消退和浸润物吸收,随后在第7天形成轻微的角膜基质混浊,以及溃疡上皮化,兔血浆 - 第14天。

结论: 当感染念珠菌属真菌时,用富含血小板的兔血浆治疗会导致真菌性角膜炎模型中角膜缺损的上皮化加速。

关键词: 角膜真菌病, 真菌性角膜炎, 血浆疗法, 血浆佐剂。

利益冲突: 无。

财务透明度: 作者对所提供的材料或方法没有经济利益。

**Abstract. Purpose of the work:** to investigate and compare experimentally the wound-healing effect of plasma adjuvants on a model of fungal keratitis when infected with fungi of the genus *Candida* spp.

**Material and methods:** a model of fungal keratitis was created in 18 rabbits (18 eyes) of the Soviet chinchilla breed. Photo documentation of the corneas of 8 rabbits (8 eyes) was carried out after the experimental use of rabbit plasma

*in the treatment of fungal keratitis, and 8 rabbits (8 eyes) after the use of rabbit plasma enriched with platelets. In order to prevent the development of secondary infection, all rabbits were instilled with a 0.3% solution of Tobramycin, 1 drop 4 times a day during the entire period of the experiment. Two rabbits (2 eyes) served as controls: the infected eyes were left without treatment. The animals were monitored daily for 21 days. On days 2, 3, 5, 7, 14 and 21 after the experimental use of plasma, macroscopic changes in the cornea were recorded.*

**Results:** *the features of the course of reparative processes in fungal keratitis were established depending on the type of plasma used. Rabbit plasma, enriched with platelets, led to the resolution of edema and resorption of the infiltrate, followed by the formation of slight opacification of the corneal stroma, as well as epithelization of the ulcer on the 7th day, rabbit plasma - on the 14th day.*

**Conclusion:** *therapy with rabbit plasma enriched with platelets leads to more accelerated epithelization of the corneal defect in a model of fungal keratitis, when infected with fungi of the genus Candida spp.*

**Keywords:** *keratomycosis, fungal keratitis, plasma therapy, plasma adjuvants.*

*Conflict of interest: none.*

*Financial transparency: none of the authors has a financial interest in the materials or methods presented.*

## **Introduction**

Infectious keratitis is the most common cause of corneal opacities and the fifth leading cause of blindness, accounting for 3.5% (36 million) of all blind people as of 2015 [1]. The main predisposing factors include wearing contact lenses, eye trauma and ocular surface diseases. The most common pathogens are Staphylococcus aureus (SA), Pseudomonas aeruginosa (PA), Fusarium spp., Candida spp., and Acanthamoeba spp. [2].

According to the observations of various researchers, three large etiological groups remain relevant - infectious keratitis is most often caused by bacterial, viral, fungal agents [3, 4], but their ratio is undergoing changes. Over the past decades, the proportion of fungal keratitis has increased [5, 6]

Unfortunately, reliable epidemiological data on infectious keratitis are difficult to collect, since most data on corneal pathology include traumatic, infectious, inflammatory and hereditary diseases.

The incidence of microbial keratitis varies worldwide. In developed countries, incidence was reported at 27.6 per 100,000 years in the United States (US) in 1999, 40.3 per 100,000 in England in 2006, and 6.6 per 100,000 in Australia in 2015 [7], [8]. The opposite situation is observed in developing countries in Asia, where infectious keratitis poses a public health threat. These countries face difficulties in accessing health care, poor health outcomes and a higher proportion of

agricultural workers, with incidence as high as 113 per 100,000 in Madurai, Tamil Nadu, India; 339 per 100,000 in Bhutan; 710 in Burma and 799 in Nepal [7, 9, 10].

Predisposing factors, causative agents, and clinical outcomes vary by geographic location, occupation, available medications, and gross national product income.

Fungal keratitis is a devastating disease and one of the leading causes of blindness in Asia [11, 12]. Fungal keratitis accounts for 6% to 53% of all cases of infectious keratitis, depending on the country [11 – 14].

A study conducted in India found that 90% of cases of keratomycosis were associated with trauma, while in the United States the figure was 11-14%.

The true burden of the disease worldwide is difficult to ascertain, but poor rural and agricultural populations are likely to be disproportionately affected.

Thus, the treatment of keratomycosis does not accept patterns. Also, do not be overly suspicious and start antifungal therapy without laboratory confirmation. If a fungal ulcer or keratitis is detected, an antifungal treatment regimen must be immediately prescribed; however, the choice of antifungal agents available for ophthalmic use is severely limited.

The problem of diagnosing and treating bacterial keratitis in most cases is solved with the help of a widely available diagnostic and therapeutic arsenal of tools to combat its manifestations and complications. In routine clinical practice, the cultural method of studying materials is used, and the possibilities of therapy are practically unlimited due to the availability of wide-spectrum antibacterial ophthalmic solutions, including drugs from the groups of chloramphenicols, tetracyclines, sulfonamides, aminoglycosides, macrolides, and fluoroquinolones. The problem of resistance of pathogens of bacterial keratitis to antibacterial drugs is of great interest [15 – 18]. Of course, this issue deserves in-depth research.

In the international and domestic literature, publications devoted to the study of the problem of diagnosis and treatment of *Acanthamoeba* and fungal keratitis are of particular interest [19 - 21]. The history of the study of keratomycosis dates back to the end of the 19th century. The first mention of hypopyonkeratitis caused by the mold fungus *Aspergillus* is considered to be the message of T. Leber (1897) [22, 23]. In the domestic literature, corneal aspergillosis was first described by L.V. Popov (1887), and subsequently - E.I. Markov (1900). Russian scientists L.P. Korsh (1901) and A.G. Trubin (1909) were able to demonstrate the etiological role of fungi by experimentally infecting healthy eyes of animals with them.

During the same period, research was carried out in Europe on the hereditary genesis of keratitis; the first mention was made in 1928 by the famous Swiss ophthalmologist Adolphe Franceschetti, when he reported on a family, 6 generations of which were under his supervision with a dominant type of inheritance of the disease [24].

In 2000, a group of German ophthalmologists SchnitzlerE, SpörlE, SeilerT first used cross-linking of corneal collagen (CCC) with riboflavin to treat corneal ulcers.

This discovery contributed to the development of a new direction in the search for effective treatment of infectious keratitis and corneal ulcers resistant to conservative therapy [25, 26].

In 2008, S. Martins et al. demonstrated the antimicrobial efficacy of CCC against common pathogenic agents. The study population included keratitis due to PA, SA, Staphylococcus epidermidis (SE), methicillin-resistant S. aureus (MRSA), multidrug-resistant P. aeruginosa (MDRPA), drug-resistant Streptococcus pneumoniae (DRSP) and Candida albicans (CA). CRL was effective against SA, SE, PA, MRSA, MDRPA, DRSP, but was ineffective against SA [27].

The following years were marked by the identification of rare cases of fungal keratitis. For the first time, semiotics was described, assumptions were made about the role of corneal trauma and the connection between this pathology and antibiotic therapy. In sources from 1959, irrational antibiotic therapy and local use of corticosteroids are already indicated as the main risk factors for the development of keratomycosis. Currently, risk factors also include the spread of operations on the cornea, in particular, penetrating keratoplasty [22, 28].

The purpose of this work was to determine the effectiveness of our proposed method for treating fungal keratitis using plasma adjuvants.

### **Materials and methods**

We proposed an experimental method for the treatment of fungal keratitis, the causative agent of which is fungi of the genus Candida spp. Having created a model of fungal keratitis in 18 rabbits (18 eyes) of the Soviet chinchilla breed, according to patent No. 2,746,647, we began treating it with the help of rabbit plasma adjuvants [6].

In 8 rabbits (8 eyes), rabbit plasma was used as therapy; in the other 8 rabbits (8 eyes), rabbit plasma enriched with platelets was used. In order to prevent the development of secondary infection, all rabbits were instilled with a 0.3% solution of Tobramycin, 1 drop 4 times a day during the entire period of the experiment. Two rabbits (2 eyes) served as controls: the infected eyes were left without treatment.

The animals were monitored daily for 21 days. On days 2, 3, 5, 7, 14 and 21 after the experimental use of plasma, macroscopic changes in the cornea were recorded.

### **Results and discussion**

As a result of the experimental use of plasma adjuvants in the treatment of keratomycosis on a model of fungal keratitis, the following features of the course of reparative processes were established depending on the type of plasma used:



- rabbit plasma enriched with platelets led to the resolution of edema and resorption of the infiltrate, followed by the formation of slight clouding of the corneal stroma, as well as epithelization of the ulcer on the 7th day;
- rabbit plasma - on the 14th day.

The use of the proposed method in the treatment of keratomycosis allows one to simultaneously accelerate and increase the percentage of cure of infectious keratitis in rabbits. The results obtained are encouraging and allow us to hope that the described method can also be used in the clinical practice of an ophthalmologist.

### Conclusion

The experimental use of plasma adjuvants in the treatment of keratomycosis in a model of fungal keratitis has shown encouraging results: therapy with rabbit plasma enriched with platelets leads to more accelerated epithelization of the corneal defect in a model of fungal keratitis, when infected with fungi of the genus *Candida* spp., than in plasma treatment.

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角膜地形图参数对眼压眼压的影响分析

**ANALYSIS OF THE EFFECT OF CORNEOTOPOGRAPHIC  
PARAMETERS ON TONOMETRIC INTRAOCULAR PRESSURE**

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抽象的。目的 - 研究角膜地形图参数对眼压眼压 (IOP) 的影响。

方法。该研究在俄罗斯卫生部喀山国立医科大学进行,该大学位于以 E.V. 教授命名的 SAHI RCOH MOH RT 临床基地。阿达梅克,喀山市。对 500 名患者 (1000 只眼睛) 使用角膜地形图仪 (WaveLight ALLEGRO Topolyzer VARIO, Alcon) 的 7 种角膜地形图指标和使用 Maklakov 眼压计 (Н Г М 2-«О Ф Т-П») 测量眼压的眼压数据进行了研究。样本人群中,同时患有正视屈光的患者8只眼 (0.8%), 屈光不正的患者992只眼 (99.2%), 其中: 近视屈光978只眼 (97.8%), 14只眼 (1.4%) 眼睛有孤立性屈光并伴有近视散光。889只眼 (88.9%) 合并近视屈光和近视散光。

结果。基于对500名患者 (1000只眼) 的7个角膜地形图指标和眼压眼压值的分析,确定了6个研究的角膜参数的最大影响,例如: ISV (表面方差指数); IVA (垂直不对称指数); KI (圆锥角膜指数); CKI (中央圆锥角膜指数); IHA (身高

不对称指数)； Rmin (最小矢状曲率)，关于眼压值。

结论。 根据获得的结果，我们确定了角膜地形参数对眼压测量眼压的影响，并根据我们开发的原始公式创建了校正眼压值的公式： $P_t$  角膜地形图校正 =  $P_t + (\pm ISV p) + (\pm IVA p) + (\pm KI p) + (\pm IHA p) + (\pm Rmin p)$ 。

关键词：角膜地形图、角膜、眼压、眼压测量、重新计算。

利益冲突：作者声明不存在利益冲突。

资助：作者没有收到这项工作的具体资助。

**Abstract. The aim** – to study the influence of corneotopographic parameters on tonometric intraocular pressure (IOP).

**Methods.** The study was conducted at the Kazan State Medical University of the Ministry of Health of Russia, at the clinical base of the SAHI RCOH MOH RT named after Professor E.V. Adamyuk, city of Kazan. A study of 7 corneotopographic indicators of a corneotopograph (WaveLight ALLEGRO Topolyzer VARIO, Alcon) and data of tonometric intraocular pressure using a Maklakov tonometer (НГМ2-«ОФТ-П») was carried out in 500 patients (1000 eyes). Among the sample population there were patients with both emmetropic refraction - 8 eyes (0.8%), and patients with refractive errors - 992 eyes (99.2%), among them: 978 eyes (97.8%) had myopic refraction, 14 (1.4%) eyes had isolated refraction with myopic astigmatism. 889 eyes (88.9%) combined myopic refraction with myopic astigmatism.

**Results.** Based on the analysis of 7 corneotopographic indicators and tonometric IOP values, 500 patients (1000 eyes), the greatest influence of 6 studied corneal parameters was determined, such as: ISV (index of surface variance); IVA (index of vertical asymmetry); KI (keratoconus index); CKI (central keratoconus index); IHA (index of height asymmetry); Rmin (minimum sagittal curvature), on intraocular pressure values.

**Conclusions.** Based on the results obtained, we determined the effect of topographic parameters of the cornea on tonometric IOP, and created a formula for correcting intraocular pressure values based on the original formula we developed:  $P_t$  corneotopographic corrected =  $P_t + (\pm ISV p) + (\pm IVA p) + (\pm KI p) + (\pm IHA p) + (\pm Rmin p)$ .

**Keywords:** corneotopography, cornea, intraocular pressure, tonometry, recalculation.

**Conflict of interest:** the authors declare that there is no conflict of interest.

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## Introduction

Intraocular pressure is the pressure exerted by aqueous humor on the eyeball from the inside, as a result of its production and outflow from the eye. The physiological fluctuation of intraocular fluid ensures the constancy of circulating nu-

trients and normal trophism of intraocular tissues [1]. Intraocular pressure (IOP) values can be influenced by many different factors, both external and internal [2]. There are a large number of different types of tonometers for measuring IOP [3], which are divided into contact and non-contact [4]. On the territory of the Russian Federation, the most commonly used for recording intraocular pressure indicators is the Maklakov tonometer.

According to many researchers, all currently existing methods for measuring intraocular pressure have an error that is associated with the individual characteristics of the cornea, for example, the thickness of the cornea in each individual patient. Thus, with a “thick” cornea, overdiagnosis of glaucoma may occur, with the decision to prescribe lifelong treatment, and, on the contrary, with a “thin” cornea, a delayed diagnosis of glaucoma is possible [5-6]. To take into account the influence of corneal thickness, the Eller correction factor was developed for the Goldman tonometer, which allows recalculation of IOP values when the average pachymetry values deviate [7]. But taking into account only pachymetric data for recalculating IOP, despite its significance, does not take into account many other corneal parameters that affect the reliability of intraocular pressure values.

Today, there are a large number of modern methods for assessing the topographic features of the cornea, but only some of the topographic parameters are taken into account in their influence on IOP indicators. For example, biomechanical variability in the thickness, stiffness, curvature of the cornea or corneal tear film can lead to numerous errors when measuring intraocular pressure with applanation tonometers [8]. Thus, with an increase in corneal curvature, intraocular pressure indicators decrease, especially with contact tonometry [9]. Corneal radius has a negative correlation with intraocular pressure measurements [10]. If pachymetry and corneal hysteresis are taken into account in clinical practice for a more accurate calculation of IOP values, then many other parameters are usually not taken into account. Since there is a global trend towards increasing myopization of the population in many countries, according to some data, by 2050 it is expected that more than half of the world’s population will have myopia [11], so the number of people who will be planned and undergo excimer laser vision correction, in which The architectonics of the cornea changes forever and will increase. Changes in the architectonics of the cornea will lead to changes in IOP parameters, including with the applanation tonometry method [12]. IOP and biomechanical properties of the cornea also change after cataract surgery [13]. Since, of course, there is a global trend towards an increase in surgical interventions on the cornea, we consider the study of topographic indicators for the values of tonometric intraocular pressure more than relevant today.

The purpose of the study was to study the influence of corneotopographic indicators on tonometric intraocular pressure, with the subsequent possibility of adjusting intraocular pressure indicators.

**Material and methods.** The study was carried out at the Federal State Budgetary Educational Institution of Higher Education Kazan State Medical University of the Ministry of Health of the Russian Federation, at the clinical base of the State Autonomous Institution of the Republican Clinical Hospital of the Ministry of Health of the Republic of Tatarstan named after Professor E.V. Adamyuk, Kazan city.

The sample of 500 people included persons over 18 years of age. Among the sample population there were patients with both emmetropic refraction - 8 eyes (0.8%), and patients with refractive errors - 992 eyes (99.2%), among them: 978 eyes (97.8%) had myopic refraction, 14 (1.4%) eyes had isolated refraction with myopic astigmatism. 889 eyes (88.9%) combined myopic refraction with myopic astigmatism. No other visual pathology was identified in patients at the time of the study. The exclusion criteria from the sample were any surgical interventions on the organ of vision and an established diagnosis of glaucoma, as well as patients with corneal pathologies (such as keratoconus, keratoglobus and other diseases affecting the architectonics of the cornea). Persons with diabetes mellitus types I and II, chronic autoimmune and systemic diseases were also excluded from the study. Women made up 58% (290 people), men – 42% (210 people).

We studied 7 indicators of the corneotopograph (WaveLight ALLEGRO Topolyzer VARIO, Alcon, USA), and tonometric intraocular pressure data using a Maklakov tonometer (NGm2-OFT-P, Russia) in 500 patients (1000 eyes). Corneotopograph indicators: 1) ISV (index of surface deviation, dimensionless); 2) IVA (index of vertical asymmetry, expressed in mm); 3) KI (keratoconus index, dimensionless); 4) CKI (central keratoconus index, dimensionless); 5) Rmin (smallest radius of curvature, expressed in mm); 6) IHA (height (height) asymmetry index, dimensionless); 7) IHD (index of height (height) decentration, dimensionless).

Tonometric intraocular pressure was measured using a standard method, with a 10 gram Maklakov tonometer (NGm2-OFT-P, Russia, Moscow), with preliminary instillation of a 0.4% oxybuprocaine solution into the conjunctival cavity, for the purpose of local anesthesia, immediately after corneotopography .

The obtained data were structured in a Microsoft Excel 2016 table. For statistical calculations, we used the R 4.2.2 environment (R Foundation for Statistical Computing, Vienna, Austria). For correlation analysis, Spearman's rank correlation coefficient  $\rho$  with the corresponding 95% confidence interval was used. To carry out regression analysis, linear regression models were used; regressors with right-sided skewness of the sample distribution were included in the models after log2 transformation (the skewness coefficient value of 1.96 was used as a threshold value). The association was considered statistically significant at  $p < 0.05$ .

**Results.** Based on the statistical analysis, we obtained the following data, which are presented in Table 1.

**Table 1.**

*Results of correlation analysis of Topolyzer parameters and tonometric ocular pressure (Pt).*

Topographic parameters of the anterior surface of the cornea			Pt dependence		
name	interval	mode	$\rho$	[95% CI]	p
ISV	1 – 51	20	-0,17	[-0,23; -0,11]	<0,001
IVA	0.02 – 0.8	0.11	-0,19	[-0,25; -0,13]	<0,001
KI	0,95 – 1,11	1,01	-0,08	[-0,14; -0,02]	0,012
CKI	1 – 1,02	1,01	-0,12	[-0,18; -0,06]	<0,001
Rmin	4,89 – 8,35	7,54	-0,16	[-0,22; -0,10]	<0,001
IHA	-2,0 – 26,9	4,5	-0,13	[-0,19; -0,07]	<0,001
IHD	0 – 0,023	0,004	-0,05	[-0,11; 0,02]	0,146

CI – confidence interval

$\rho$  – Spearman’s rank correlation coefficient

p – statistical significance

Among all 7 corneal parameters, a statistically significant linear association was found only for 6 parameters: ISV, IVA, KI, CKI, Rmin, IHA.

A statistically significant association was identified with an increase by each unit in such parameters as: ISV, KI, Rmin, IHA with a decrease in tonometric IOP: ISV by 0.045 mm Hg; KI at 6.97 mm Hg; Rmin per 1 mm Hg; IHA by 0.05 mm Hg. An increase in IVA by 2 times was statistically significantly associated with a decrease in tonometric IOP by 0.44 mm Hg. An increase in CKI by 0.1 was statistically significantly associated with a decrease in tonometric IOP by 4.38 mm Hg.

Accordingly, if the values deviate from the sampling mode, all of the above parameters and indices, it is necessary to predict the IOP adjustment. The significant influence of other indices and corneal parameters was not statistically significant.

**Discussion.**

Based on the above parameters and analysis of the data obtained, we have derived the following formula for adjusting tonometric intraocular pressure indicators, which can be designated as:

$Pt_{\text{corrected}} = Pt + (\pm ISV p) + (\pm IVA p) + (\pm KI p) + (\pm CKI p) + (\pm IHA p) + (\pm Rmin p)$ , where  $Pt_{\text{corrected}}$  is the corrected tonometric intraocular pressure based on individual corneotopographic indicators. Corneal indices and indicators (ISV p, IVA p, KI p, CKI p, IHA p, Rmin p) in this formula imply values in mm Hg, which are obtained by analyzing the individual parameters of the cornea and are determined according to the above criteria based on the mode of the index or indicator.



Since the KI indicator and the CKI indicator (which were initially taken into account in statistical processing) are analogues of each other, we consider it advisable to transform the formula into the following form:

$$P_t \text{ corneotopographic corrected} = P_t + (\pm \text{ISV } p) + (\pm \text{IVA } p) + (\pm \text{KI } p) + (\pm \text{IHA } p) + (\pm \text{Rmin } p)$$

As an example for using the formula in practice, you can simulate a clinical case. In patient B., during an annual examination in a clinic, a tonometric intraocular pressure of 26 mm Hg was found to be outside the normal range, the patient was sent for additional examination to the republican ophthalmological clinic, with a diagnosis of: Suspicion of glaucoma in both eyes, where the patient was not confirmed with a diagnosis during a comprehensive examination for glaucoma using optic disc tomography and computer perimetry, but the diagnosis of “ophthalmic hypertension” was left, then the patient was recommended to undergo studies of the thickness and topography of the cornea, but the thickness turned out to be within the physiological norm of 510 nm, which does not require adjustment and recalculation of IOP downwards. On the corneotopograph, the ophthalmologist drew attention to a number of indicators, namely: Rmin is equal to 5.54, which was beyond the statistical average and its high degree of correlation with tonometric intraocular pressure and led to an overestimation of intraocular pressure by 2 mm Hg, and the ISV index is 8, which went beyond the statistical average and its high degree of correlation with tonometric intraocular pressure and led to an overestimation of intraocular pressure by 0.54 mm Hg, and also identified indices KI equal to 1.01, IVA equal to 0.11, IHA equal to 4.5, CKI equal to 1.01, these parameters do not go beyond the statistical average and do not require consideration in the recalculation of tonometric IOP.

Using our formula  $P_t \text{ corneotopographic corrected} = P_t + (\pm \text{ISV } p) + (\pm \text{IVA } p) + (\pm \text{KI } p) + (\pm \text{IHA } p) + (\pm \text{Rmin } p)$ , you can recalculate the IOP  $P_t \text{ corneotopographic corrected} = P_t + (-0.54 \text{ mm Hg}) + (0 \text{ mmHg}) + (0 \text{ mm Hg}) + (0 \text{ mm Hg}) + (-2 \text{ mm Hg}) = 23.46 \text{ mm Hg}$ .

Taking this into account, the IOP indicator can be assessed as not equal to 26 mm Hg, and equal to 23.46 mm Hg, which is not ocular hypertension.

**Conclusion.** The data from our research and analysis of the data obtained tell us about the significant influence of corneotopographic parameters of the cornea on the values of tonometric intraocular pressure. Based on the results obtained, we have identified a pattern that allows us to assert the need to take into account the influence of corneal parameters and indices on intraocular pressure values. A formula has been created:  $P_t \text{ corneotopographic corrected} = P_t + (\pm \text{ISV } p) + (\pm \text{IVA } p) + (\pm \text{KI } p) + (\pm \text{IHA } p) + (\pm \text{Rmin } p)$ , to recalculate intraocular pressure based on the specified corneotopographic values.

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城市农场: 大都市城市空间中复杂系统的可靠性和安全性  
**CITY FARMS: RELIABILITY AND SAFETY OF A COMPLEX  
SYSTEM IN THE URBAN SPACE OF A METROPOLIS**

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注解。 分析了一种流行的环境现象——城市农业的产生和发展的原因和机制。 对 RSCI 出版物和俄罗斯紧急情况部关于该主题的科学会议材料进行了分析。 搜索深度为10年。 据证实,自 2017 年以来,俄罗斯联邦科学界对城市农场安全问题的兴趣不断增长,但尚未制定评估其可靠性和安全性的标准。 已为城市农民制定了防火措施建议。

关键词: 城市生态、城市农场、安全、可靠性、高分子复合材料、防火。

**Annotation.** *The causes and mechanisms of the emergence and development of a popular environmental phenomenon - city farming - are analyzed. An analysis of RSCI publications and materials of scientific conferences of the Russian Ministry of Emergency Situations on this topic was carried out. The search depth was 10 years. It has been established that in the Russian Federation, the interest of the scientific community in the problem of the safety of city farms has been growing since 2017, but criteria for assessing their reliability and safety have not been developed. Recommendations have been developed for city farmers on fire prevention measures.*

**Keywords:** *urban ecology, city farms, safety, reliability, polymer composite materials, fire prevention.*

Modern trends in urban planning and environmental behavior of residents of large cities are characterized by innovation. These innovations are associated with two factors: global warming and the widespread digitalization of all aspects of human life, including agricultural technologies, and consist in the organization of city farms inside residential, administrative and other premises unsuitable for agriculture. The possibility of such a transformation of the environment was predicted

by the famous environmental scientist V.I. Vernadsky at the beginning of the 20th century. Almost a century later, at the beginning of the 21st century, the scientist's forecast moved to a new stage of scientific and technological progress and became an element of planning the practical activities of residents of large cities, a problem of operational and strategic management by the leadership of megacities. In his work "The Agrarian Problem and Scientific Research Work" V.I. Vernadsky wrote: "The agrarian question equally consists of three equal parts: 1) the distribution of land convenient for agricultural use; 2) increasing its productivity and 3) transforming land areas unsuitable for agriculture into suitable areas" [1, p. 152], "The conviction must penetrate into the public consciousness that in this area the state has approached the solution of issues in relation to which it has neither accumulated experience nor scientific knowledge. Therefore, it must quickly and firmly organize the acquisition of this knowledge" [1, p. 154].

In modern design, the equipment of city farms is carried out by the owners of the premises. The use of polymer composite materials in them, the creation of an artificial microclimate, the use of chemical fertilizers, and the saturation of computer equipment and electrical equipment are not regulated by existing legislative acts on safety, fire safety, and urban planning standards. Therefore, the purpose of this work was to study the phenomenon of ecological city farms from the point of view of its comprehensive safety.

The objectives of the research work were formulated as follows: 1) systematize information about the thermodynamic characteristics of urban ecosystems as an objective basis for the development of city farming; 2) create a ranking of city farm options present today in the structure of urban ecology; 3) based on a scientometric analysis of publications in the RSCI database, assess the involvement of the scientific community in resolving issues of comprehensive and fire safety of city farms in megacities; 4) summarize the fire hazard features of city farms as an innovative ecological object of the urban environment with a highly developed IT infrastructure; 5) develop recommendations for organizing fire safety in city farms and test them in dialogue with an interested audience.

Material and method. The source of information was open Internet sites, publications of the RSCI database, as well as reports of employees of the Ministry of Emergency Situations of Russia, the Republic of Kazakhstan and the Republic of Belarus at specialized scientific and practical conferences. The depth of the information search was 10 years based on the RSCI database (for 2013-2022) and 3 years based on materials from departmental conferences (2021-2021 inclusive).

Content analysis of reports at scientific and practical conferences was carried out in the format of participant observation in the form of face-to-face, remote and correspondence participation. The development includes specialized conferences of the following organizations: Federal State Budgetary Institution "All-Russian

Research Institute for Civil Defense and Emergency Situations of the Ministry of Emergency Situations of Russia” (Federal Center for Science and High Technologies), Federal State Budgetary Institution “All-Russian Order of the Badge of Honor” Research Institute of Fire Defense of the Ministry of Emergency Situations of Russia”, Academy of Civil Protection of the Ministry of Emergency Situations of Russia, Academy of the State Fire Service of the Ministry of Emergency Situations of Russia, St. Petersburg University of the State Fire Service of the Ministry of Emergency Situations of Russia, Siberian Fire and Rescue Academy of the State Fire Service of the Ministry of Emergency Situations of Russia, Ivanovo Fire and Rescue Academy of the State Fire Service of the Ministry of Emergency Situations of Russia, Ural Institute of the State Fire Service of the Ministry of Emergency Situations of Russia, Research Center of the Academy of Civil Defense named after M. Gabdullina Ministry of Emergency Situations of the Republic of Kazakhstan, State educational institution “University of Civil Protection of the Ministry of Emergency Situations of the Republic of Belarus”.

The analytical development includes 284 publications from the RSCI database and materials (reports and publications) from 27 scientific events of departmental universities. The analytical review of this study included reports on the characteristics of fires in buildings that use modern building and finishing materials made from polymer composite materials, which are also raw materials in the production of greenhouses, greenhouses and structural elements of city farms.

Results. It has been established that the phenomenon of city farms is a response to the changing environment of mankind in the form of global warming, the widespread spread of IT technologies, the creation of new materials and the unlimited opportunity for city residents to use various polymer composite building materials for finishing residential premises. We have found that the phenomenon of city farming is popular among residents of megacities all over the world, but in Russia it has been present relatively recently. The growing interest of the scientific community in the number of publications in the RSCI database has been observed since 2017. The dependence of the number of publications on time is linear and is described by the formula  $y = 17.429x - 35150$  with high values of the approximation reliability ( $R^2 = 0.98$ ). City farms are most widespread in the structure of urban spaces in Moscow, Novosibirsk, and Bryansk. In recent years, their popularity has been growing among residents of the Urals.

The novelty of the city farms phenomenon, its structural and functional heterogeneity is realized against the background of the lack of standardization of the components of city farms as a complex ecological system. Acquaintance with Boarding websites and popular science periodicals made it possible to establish that alternative to traditional methods of obtaining agricultural products are becoming popular all over the planet. According to research firm Grand View Re-

search, the global city farm market was valued at \$4.34 billion in 2021 and the segment is expected to grow at a compound annual growth rate of 25.5% from 2022 to 2030. In Europe, the share of such farming is 10-20% of the total. According to experts, by 2022 Russia will take up to 10-15% of the global organic products market, which is equivalent to 20-30 billion dollars. City farms can be placed in any enclosed space: on the territory of an old factory, a warehouse, a basement, or even an office. The microclimate inside the greenhouse is created and controlled depending on the type of plant remotely from a computer; Instead of soil, plant roots are irrigated with an aqueous solution of chemicals of a certain concentration. Fertilizer combinations completely replace the presence of soil and soil required in traditional farming. Greenhouses on roofs - they are popular in large cities: New York, Rotterdam, Hong Kong. In Russia in 2020, it was allowed to use the roofs of residential buildings for landscaping. Theoretically, vertical farms could also appear there.

Functionally, city farms are designed to cater to various needs of city dwellers, including the need for relaxation, leisure, recreation, self-expression through hobbies, commercial activities, income generation, and food production. In the face of unstable regional weather conditions, rapid global climate change, and consequently increased risks in traditional agriculture, the activation of pro-ecological behavior among urban residents through urban farming holds promising prospects in terms of ensuring food security and creating a new high-profit sector of “smart agricultural technologies”.

The idea of producing food directly in the city is not new. This practice was used during times of war and food crises. In 1893, residents of Detroit, gripped by an economic depression, planted potatoes on city vacant lots. During the First and Second World Wars, “victory gardens” appeared in Great Britain, Canada and the United States, where citizens grew vegetables and fruits for the needs of the population. In 2021, this business is developing successfully in Europe, the USA and Japan. The architectural, planning and finishing forms of city farms are very diverse. City farms are usually called vertical farms. They are being built in megacities where there is not enough free land, but there are unprofitable production facilities. A vertical farm is a multi-tiered greenhouse that can be placed in any enclosed space: in an old factory, a warehouse, a basement, or even an office. The microclimate inside the greenhouse can be created and controlled independently, selecting conditions for growing a certain type of plant. Vertical city farms, compared to conventional greenhouses, allow saving space (10–20 times compared to arable farming), water (up to 95%), and wages for workers; building materials (no need to build large-scale greenhouses), simplify logistics schemes, increase the volume of products received (you can get up to 3-4 harvests per year with low risks of crop loss). Crops can be harvested all year round. Isolation from the

external environment reduces the risk of developing plant diseases and reduces the need for pesticides. Vertical farms are also used for breeding animals. City farms can be managed remotely: watering, fertilizing and other care of plants or animals occurs automatically according to specified parameters.

The disadvantages of city farms are their high cost and energy intensity, increased risks of fire and environmental safety. In addition to vertical ones, there are hydroponic, aquaponic farms, container-type farms, growing blocks, rooftop greenhouses, etc. Their reliability and safety are also not standardized. Russian legislation does not regulate their fire, environmental and comprehensive safety standards, incl. due to the lack of criteria for their reliability and survivability. The question of the need to apply theory and reliability models of complex systems to assessing the reliability characteristics of ecosystems of varying complexity was raised by the scientific community in 2019 [2]. However, publications on these topic concern ecological systems of a different scale and operating algorithms compared to city farms [3-9], and therefore cannot be completely extrapolated to this innovative element of the urban ecosystem. A systematic analysis of the structure and function of city farming is needed to highlight its critical infrastructure, weak links and risk areas for fire development and violation of the conditions for stable functioning. The analysis of publications from the RSCI database and materials from departmental conferences allows us to put forward the thesis that to describe the reliability of a city farm, it is advisable to use its complex characteristics, which include the geographical location of the object, regional characteristics of weather conditions, the heat exchange regime of the metropolis with the adjacent rural and/or industrial territory, energy intensity city farms as an object of digital agricultural technologies, studying the physical and chemical patterns of thermal destruction of building materials used in design.

The variety of structural and functional characteristics of city farms also includes a variety of polymer composite materials that are used in their creation. These materials differ from traditional building materials (wood, brick and reinforced concrete products). They differ in the conditions of heat and mass transfer in the event of fire, the phase characteristics of the occurrence of chemical reactions during fires, the proportion of the kinetic and diffusion regime of the chemical interaction of reacting substances, the presence/absence of catalysts/combustion inhibitors in their structure, etc. [10-13].

Based on the results of the analysis, we have developed a draft of practical recommendations for owners of city farms on fire prevention issues. The project was tested on the example of extracurricular activities with high school students in Omsk. The materials of the conducted research were presented at specialized scientific and practical conferences and reflected in publications [14-17]. It is planned to scale the results obtained using the capabilities of social networks.



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开发振动振幅自动控制技术振动测试装置

## DEVELOPMENT OF TECHNOLOGICAL VIBRATION TESTING UNIT FOR AUTOMATIC CONTROL OF VIBRATION AMPLITUDE

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注解。 本文介绍了开发用于长零件表面硬化的原型技术生产设备的过程, 该设备即使在外部干扰的情况下也能自动控制振动系统各个部件的振动幅度。 这种振动幅度的自动调节对于确保零件的高质量加工是必要的。 目前, 生产中提到的安装不是自动化的, 需要手动调节振幅。 振荡幅度控制采用静态自适应方法实现。

关键词: 振动、振动阻尼、振动安装、布局、振幅相等、生产过程、自动化。

**Annotation.** *This article describes the process of developing a prototype technological production plant for surface hardening of long parts with automatic control of the vibration amplitude of various components of the vibration system, even under conditions of external disturbances. This automatic adjustment of the vibration amplitude is necessary to ensure high-quality machining of parts. Currently, the mentioned installation in production is not automated and requires manual adjustment of the oscillation amplitude. The oscillation amplitude control is implemented using the static adaptation method.*

**Keywords:** *vibration, vibration damping, vibration installation, layout, amplitude equality, production process, automation.*

### Introduction

At the aircraft plant in Ulan-Ude, when carrying out technological processes related to the hardening of parts, there are many vibration installations in which it

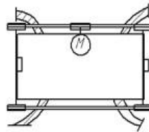
is necessary to adjust the parameters manually, which, of course, affects the efficiency of the work being carried out.

The first prototype has already been developed and, based on previous experience in constructing a layout and analyzing the modern patent base, a decision was made to implement the project with a deep modernization [1]. The prototype was a local process control point with data output on a small display and a working surface with eccentrics connected by belt drives to apply forces to excite oscillations of the vibration field.

Taking into account the presence of multiple forms and variations of prototypes, each with their own parameters such as center of gravity, moments of inertia, mass, etc. [2], our main goal is to develop an algorithm for the system's operation and a fully functioning prototype in addition to conducting successful tests of the system.

#### Improving the regulatory system

To select the type of system that directly controls the layout, two design options were proposed - acoustic and pneumatic (mechanical). The main option was to control the vibration field by changing the stiffness of the springs using compressed air. This option turned out to be more economical and less harmful to working conditions. Initial layout (Fig. 1.) consisted of two pneumatic chambers divided into sections. However, the irrational use of space for installation and compressed air supply implies a revision of the concept.



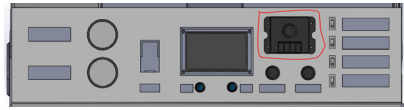
*Figure 1. Initial version*

Based on the rejection of the previous version of the engineering solution. Instead of using pneumatic chambers elongated along a horizontal plane, it was decided to install vertical chambers with elements of stiffening ribs in the amount of 4 units. Each air cylinder (made from a car boot), (Fig. 2) has a valve for supplying/discharging compressed air, and therefore, the possibility of scaling the system is provided.



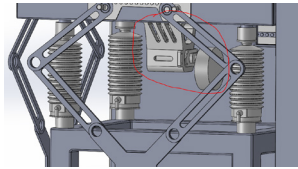
*Figure 2. Pneumatic cylinder*

The vibration exciter element is a motor with an eccentric installed under the working surface. The number of engine revolutions is regulated using a special control in the form of a dimmer (Fig. 3).



*Figure 3. Dimmer on control panel*

The installation location of the engine on the prototype is located under the working area at the intersection point of the center of mass of the complex object (Fig. 4).



*Figure 4. Mounting location for motor with eccentric*

### **Vibrating element**

The prerogative was given in favor of modular design to change the mass of the eccentric. The mass of the eccentric with mounting and motor is 0.5 kg. (Fig.5).



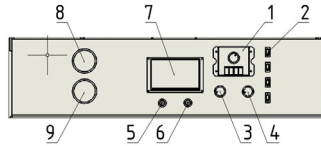
*Figure 5. Mounting location for motor with eccentric*

Based on the data obtained from past tests, a decision was made to remove the belt drive from service.

### **General view of the layout**

Control panel with remote elements influencing the technological process (Fig.6), such as: 1 - Dimmer for controlling a motor with an eccentric. 2 - Power and control mode switches. 3 - Potentiometer for the task of vibration amplitude .4 - Sound indication. 5 – Start button. 6 – Stop button. 7 - HMI Touch control pan-

el for collecting process data and providing instructions. 8,9 - Block of pressure gauges for taking physical readings of the process, power supply to the microcontroller of a separate connection circuit.



*Figure 6. Control Panel*

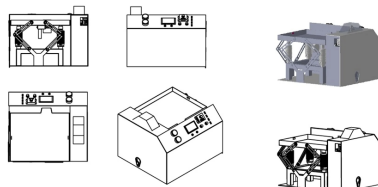
The controls at the mechanical level are automobile injectors as pneumatic valves for the inlet/outlet of compressed air, controlled using a direct current voltage of 12 V (DC). However, it is recommended to use 5/3 pneumatic distributors with a combination of an air preparation unit and throttling of compressed air flows from pneumatic cylinders, which are responsible for ensuring the necessary spring stiffness.

The stand (Fig. 7) is designed to ensure user safety.

To provide a degree of freedom in addition to the Z axis, one part of the kinematic pair “lift” was adapted by adding a joint with a degree of freedom along the Y axis moment, allowing the movement of the working surface to be fixed along the X, Y axis, but at the same time leaving the possibility of movement along the Z and Y axis moment along the Y axis, providing the necessary roll for the system to operate.

Arduino MEGA is used as a microcontroller.

Devices that measure process indicators are accelerometers and limit position sensors.



*Figure 7. Overall layout*

**Processing information from sensors**

When taking readings from sensors, we receive significant noise and sharp bursts of data, which are undesirable for ensuring high-quality implementation of automatic control of the cycle of inlet/outlet of compressed air into pneumatic cylinders.

The goal is to smooth the readings as much as possible with minimal loss of data packets coming from the sensors. One of the available options is a low-pass filter (LPF) (For example, everything above 17 Hz does not interest us and the filter removes these values) and the arithmetic average of dozens of data sampling values.

The signal is taken modulo, since we need the amplitude value of the technological process.

**Description of the control algorithm**

The main problem of the vibration technological process is its nonlinearity, therefore no truly effective solution has been synthesized. An attempt to solve this problem was to use the static adaptation method. The block diagram (Fig. 8) of the control channel is presented below [3-6]:

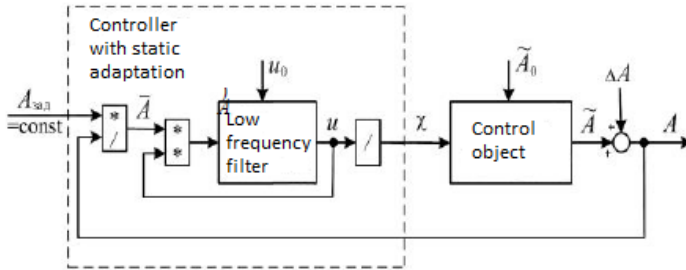


Figure 8. Block diagram

To begin with, we find the ratio of the given amplitude to the amplitude value from the control object, which passed through the data filter at the previous step

$$\bar{A} = \frac{A_{sad}}{A_{i-1}} \tag{1}$$

Next, we perform the product of the obtained value and the filter output signal. Receiving the filter input value

$$x_i = \bar{A} \times u_{i-1} \tag{2}$$

We substitute this value into the low-pass filter formula (8) for discrete implementation. We get the current filtered signal.

$$u_i = \frac{\Delta t}{\Delta t + T} x_i + \frac{T}{T + \Delta t} u_{i-1} \tag{3}$$

We find the ratio 1 from this value and obtain a control signal to increase the pressure in the chambers.

$$\chi = \frac{1}{u_i} \tag{4}$$



**Implementation of the operation of the air cylinder control system**

The stand features a compressed air delivery system to elastic chambers, which serve as the main component for interacting with the vibrational field, enabling its control through the injection and release of compressed air, thereby increasing or decreasing the stiffness of the system by controlling individual pneumatic balloons.

By sending a signal to each valve, we set a control action on the coil, which opens the flap, allowing air flow into the chamber.

To set the boundary conditions for the expansion of the pneumatic chamber, limit position sensors are used based on mechanical contact with the object.

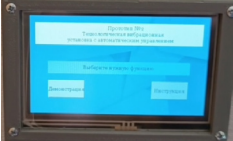
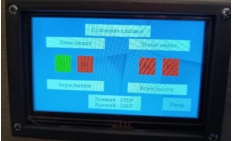
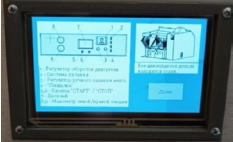
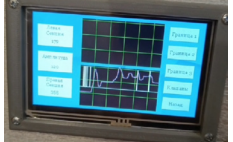
To compose all possible positions of the system, it is necessary to introduce a metric that determines the success of stabilization of the process (limiter) with an error coefficient (permissible range of values).

Then, based on inequalities with the parameters of a given amplitude and boundary values, the supply of compressed air is regulated.

**Stand visualization system**

The presence of an HMI panel with its own development environment simplifies the interaction of the microcontroller in transmitting data to the screen with the proper degree of visualization and simplifying the operation of the system as a whole. All system readings are displayed on the screen in real time.

*Table 1.*

<p>Cover page with title and choice between instruction and demonstration.</p>		<p>Screen for monitoring the operation of injectors</p>	
<p>How-to screen including one video</p>		<p>Process unit readings display screen.</p>	

**Development of a control board for the pneumatic subsystem**

To solve the problem of cyclic opening/closing of valves, it is necessary to use either ready-made versions or manually assembled ones. For example, a control board with distributed power and transistors operating in “switch” mode. The final result of the board trace is presented below (Fig. 9).

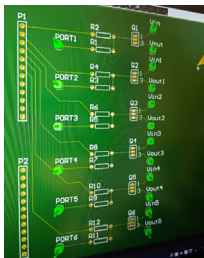


Figure 9. Virtually finished printed circuit board

### Electrical diagram of the stand

At the input of the circuit there is a connection to a 220 V mains power supply, equipped with a switch that allows the power supply to be turned off if necessary.

Next, a power supply with parameters of 12 V and 10 A is integrated into the circuit, which is designed to provide energy to the load consisting of injectors and a compressor.

The circuit also includes a variable speed motor.

The controller's control circuit includes various acceleration sensors and an alarm speaker. Acceleration sensors are used to measure changes in acceleration, allowing the controller to adapt the operation of the engine and other components in real time. The alarm speaker provides audio notifications. (Fig. 10)

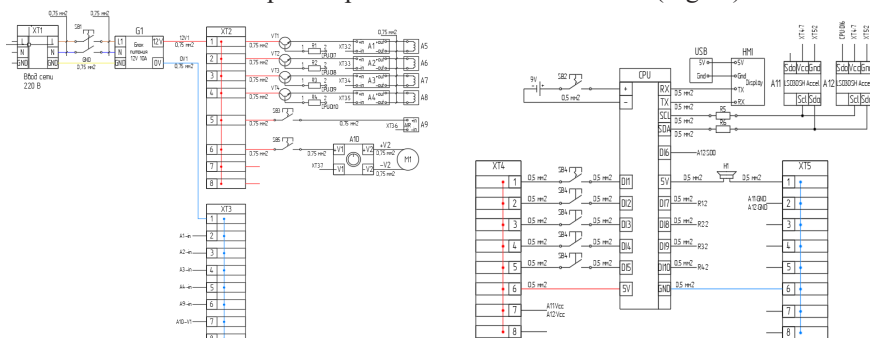


Figure 10. Electrical circuit power supply 220V and 12V

### Preliminary test of the stand

An experimental study of the stand with zero load was carried out, obtaining data when changing the angle of inclination of the working surface, and displaying the results obtained on the operator panel. The efficiency of the functioning of the mechanical and pneumatic system as a whole was assessed (Fig. 11).



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DOI 10.34660/INF.2023.43.27.170

UDC 631.816.3:635.652.2

肥料及其施用方法对菜豆产量和抗病性形成的影响  
**FACTOR OF FERTILIZERS AND METHODS OF THEIR  
APPLICATION IN THE FORMATION OF YIELD AND DISEASE  
RESISTANCE OF COMMON BEANS**

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抽象的。本文介绍了各种肥料及其施用方法对豆类新品种产量影响的研究结果。获得的数据使得可以在不同的天气条件下确定各种施肥方法的使用对产量和抗病性形成的贡献。研究表明，引入主要肥料对豆类作物的形成（增加 31.3%）比叶面施肥（增加 10.7%）更有效。N75P50K62的引入有助于显著降低豆类细菌病、根镰刀菌腐烂率和疾病发展程度。N75P50K62在现蕾期和灌浆期的抑菌效果分别为71.4%和21.2%；相对于根腐病，分别为 68.8% 和 52.2%；叶面施有机矿物肥料对减少病害发生的贡献较小：9.5% 和 9.9%；分别为 19.2% 和 23.7%。因此，合理使用肥料可以充分发挥菜豆品种的潜在生产力，提高其抗病能力。

关键词：普通豆类、矿物肥料、叶面施肥、收获、豆类细菌病、镰刀菌根腐病、有效性。

**Abstract.** *The article presents the results of a study of the influence of various fertilizers and methods of their application on the yield of new bean varieties. The data obtained makes it possible, under different weather conditions, to determine the contribution of the use of various methods of fertilization to the formation of yield and disease resistance. Revealed that the introduction of the main fertilizers are more effective for the formation of a bean crop (an increase of 31.3%) than foliar fertilizing (an increase of 10.7%). The introduction of N75P50K62 contributes to a significant reduction in the prevalence of bean bacteriosis, root fusarium rot and the degree of disease development. The effectiveness of N75P50K62 was 71.4% and 21.2% in the budding and grain filling phases with respect to bacteriosis; 68.8% and 52.2% with respect to root rot, Leaf fertilizing with organomineral fertilizers contributes less to reducing the development of diseases: 9.5% and 9.9%; 19.2 and 23.7%, respectively. Thus, the rational use of fertilizers makes it possible to fully realize the potential productivity of the common bean variety, increasing its resistance to diseases.*

**Keywords:** *common beans, mineral fertilizers, foliar feeding, harvest, bean bacteriosis, Fusarium root rot, effectiveness.*

**Introduction.** Grain legumes are the most important food crops. In world agriculture, in terms of acreage, common beans rank second among leguminous crops, second only to soybeans. In the Russian Federation, the area of distribution and cultivation of beans is insignificant and is not able to satisfy the real needs of the population [1]. Therefore, studying new varieties and adapting them to the conditions of the region is an urgent task.

In the conditions of the southern part of the Non-Black Earth Region, various aspects of agricultural technology have not been studied for new varieties of common beans, varieties Markiza, Kupava and Strela, bred by breeders of the Federal Scientific Research Center of Legumes and Groat Crops [2,3]. It is necessary to develop regulations that allow us to provide a theoretical basis for improving the technologies of their cultivation in order to increase yields and expand sown areas.

In connection with the general course of the world community towards the biologization of agriculture, modern technologies are in search of environmentally friendly methods for cultivating beans that increase productivity and plant resistance to adverse environmental factors [4,5].

Rational use of fertilizers makes it possible to fully realize the potential productivity of a crop, but currently there is a question about the deep development of a mineral nutrition system not only for individual crops, but also for varieties. Lack of understanding of the nutritional requirements of a variety when developing regulations for the use of fertilizers can initiate a decrease in yield and product quality [6]. Beans show varietal differences in nutritional level. For each variety, it is necessary to select optimal doses of phosphorus-potassium fertilizers. Unfavorable conditions for the activity of rhizobial bacteria lead to a lack of nitrogen and, as a consequence, a decrease in yield, which indicates the possibility of using nitrogen fertilizers [7].

The application of mineral fertilizers is, first of all, a direct compensation for the loss of soil minerals after their extraction by the crop. Mineral fertilizers improve the nutritional conditions of plants and constitute an important prerequisite for the implementation of field resistance of a variety to pathogens. Appropriate selection of nutrients changes the direction of biochemical processes and makes plants more or less resistant to diseases [8]. The practical application of this aspect of fertilizers together with the use of biological products, the biological effectiveness of which in some cases is less than chemical fungicides, will stabilize the phytosanitary situation in agrocenoses, reduce the pesticide load, economic costs and obtain environmentally friendly products of high quality [9,10].

**Purpose of research.** To develop environmentally friendly methods for cultivating new varieties of beans Marquise, Strela, Kupava based on the study of

various fertilizers and methods of their application to increase productivity and obtain high-quality products.

The novelty of the research lies in determining the most effective types of fertilizers and methods of their application for new varieties of common beans. An assessment was made of their influence on the formation of crops and the development of diseases.

#### **Material and research methods.**

The studies were carried out in the Oryol region, located in the central part of the Central Russian Upland within the steppe and forest-steppe zones. The climate is temperate continental.

The experiment was carried out in 4 repetitions on gray forest medium-loamy medium-cultivated soil.

The research materials were mineral fertilizers N75P50K62, organomineral fertilizers: Ultramag Combi, Biostim Grain, Ultramag Molybdenum.

The application of N75P50K62 for the planned harvest of 3 tons was carried out manually, followed by incorporation into the soil the day before sowing. Foliar feeding was carried out three times: in the phase of 2-3 leaves with organomineral fertilizers Ultramag Combi 1 l/ha + Biostim Grain + 1 l/ha + Ultramag Molybdenum 0.5 l/ha; in the phases of budding and flowering with Ultramag Combi fertilizers 1 l/ha + Biostim Grain + 1 l/ha.

For records and observations, methods of state variety testing of agricultural crops (1985) were used; the prevalence and development of root rot was recorded using the following methods: “Root rot of leguminous crops” (Kotova V.V., 1986), “Guidelines for registration testing of fungicides in agriculture” (2009), statistical processing of experimental data was carried out according to B.A. Dosphehova (1986).

#### **Research results and discussion.**

Analysis of harvest data for the period 2022-2023 revealed that the pre-sowing application of N75P50K62 for a planned harvest of 3 tons increases the yield of common beans of the Marquise variety by an average of 0.73 tons, which is 31.3%. The trend is stable and depends little on weather factors.

Foliar fertilizing with organomineral fertilizers in 2022 also contributed to an increase in yield, but half as much: by 0.42 tons, which amounted to 16% (Table 2). Foliar fertilizers introduced in 2023 in the phases of 2-3 leaves (06/08), budding (06/21) and flowering-beginning of bean formation (04/07) contributed to a slight increase in yield by 4.5% (Table 1), which may be due to the characteristics weather conditions in 2023: dry weather in the first and second ten days of June, when foliar feeding was carried out, did not contribute to the absorption of nutrients by plants through the leaves. The average increase in yield when applying foliar fertilizers over two years was 10.7%. It can be assumed that the influence of this factor is more dependent on weather conditions.

Pre-sowing application of N75P50K62 for a planned harvest of 3 tons increased the yield for beans of the Kupava variety by 44.3%, Strela - 42.9%.

Foliar feeding in the phase of 2-3 leaves (06/08), budding (06/21) and flowering-beginning of bean formation (07/04) with organomineral fertilizers contributed to a slight increase in yield: Kupava - by 6%, Strela - by 7.6% (Table 1).

**Table 1**  
*The influence of fertilizers and methods of their application on the yield of new varieties of beans, 2022-2023*

№	Variety	Options	2022			2023			average		
			t/ha	increase		t/ha	increase		t/ha	increase	
				t/ha	%		t/ha	%		t/ha	%
1	Marquise	control	2,63	-	-	2,02	-	-	2,33	-	-
2		NPK	3,44	0,81	31	2,68	0,66	32,6	3,06	0,73	31,3
3		foliar fertilizers	3,05	0,42	16	2,11	0,09	4,5	2,58	0,25	10,7
		least significant difference <sub>05</sub> – t/ha	0,3			0,4					
4	Kupava	control	-			1,610	-	-	-		
5		NPK	-			2,323	0,713	44,3	-		
6		foliar fertilizers	-			1,705	0,095	6	-		
		least significant difference <sub>05</sub> – t/ha	-			0,21					
7	Strela	control	-			1,986	-	-	-		
8		NPK	-			2,837	0,851	42,9	-		
9		foliar fertilizers	-			2,136	0,15	7,6	-		
		least significant difference <sub>05</sub> – t/ha	-			0,37			-		

Thus, the application of N75P50K62 for a planned harvest of 3 tons is more effective, but if the number of fertilizers for application is limited, foliar feeding can to some extent optimize mineral nutrition during the growing season, compensating for the decrease in yield.

The addition of NPK contributed to a significant reduction in the prevalence of bean bacteriosis, which is also reflected in yield indicators. A study of the influence of various forms of fertilizers and methods of their application on reducing the development of diseases for the period 2022-2023 showed that the pre-sowing application of N75P50K62 for a planned harvest of 3 tons contributed to a significant reduction in the development of bacteriosis: by 71.7% in the budding phase and significantly - by 21.2% during the grain filling phase. Foliar feeding reduces



the degree of development of bean bacteriosis by 9.5 and 9.9% in the corresponding periods (Table 2).

The same trend is observed in the Kupava and Strela varieties, the study of which was carried out in 2023. The prevalence of bean bacteriosis in the butanization phase decreases by 60.5% compared to the control on the Kupava variety; by 51.8% on the Strela variety, and therefore the degree of disease development decreases: Kupava variety by 72.2% in the budding phase and by 17.0% in the filling phase; Variety Strela - by 68.2% in the budding phase and by 21.2% in the filling phase (Table 2).

Foliar fertilizers also helped reduce infestation and disease development, but to a lesser extent. On the Kupava variety in the budding phase, the prevalence of the disease decreased by 13.6%, the development of the disease by 5.6%; during the grain filling phase, the development of the disease is 13.8% less than control. On the Strela variety, prevalence is reduced by 22.8%, development by 9.1% and 11.7%, respectively. Thus, foliar feeding also contributed to a decrease in the degree of infection and the degree of disease development, but to a lesser extent (Table 2).

**Table 2**  
*Development of bacteriosis of common beans depending on methods of fertilization, 2023*

Variety		Options	Prevalence,%		Development of the disease,%		efficiency,%	
			budding phase	filling phase	budding phase	filling phase	budding phase	filling phase
Marquise	2023	control	7,5	98,2	1,9	28,1	-	-
		NPK	2,4	93,3	0,5	24,2	73,7	13,9
		foliar fertilizers	6,7	93,8	1,7	25,4	10,5	9,6
	2022	control	11,5	96,6	2,3	32,2	-	-
		NPK	3,9	99	0,7	23,3	69,6	27,6
		foliar fertilizers	10,5	100	2,1	28,9	8,7	10,3
Kupava	2023	control	8,1	98,3	1,8	24,6	-	-
		NPK	3,2	98,2	0,5	20,4	72,2	17,0
		foliar fertilizers	7,0	93,3	1,7	21,2	5,6	13,8
Strela	2023	control	7,9	100	2,2	26,5	-	-
		NPK	3,8	99,8	0,7	21,0	68,2	21,2
		foliar fertilizers	6,1	100	2,0	23,4	9,1	11,7

As a result of surveys on the infestation of beans with Fusarium root rots in 2023, it was revealed that the application of basic fertilizer helps to reduce the prevalence of root rots on beans of the Marquise variety, which helps to increase

the yield. In the variant of pre-sowing application of fertilizer, the prevalence of the disease in the budding phase was lower than the control by 42.3%, in the filling phase – by 27.8%. The development of the disease decreases by 68.8% in the budding phase and by 52.8% in the grain filling phase. On beans of the Kupava variety, the prevalence is 56.5% and 26.0%; development - by 37.9% and 50.2%, respectively. On beans of the Strela variety, the prevalence is 69.8% and 42.0%; development - by 56.8% and 48.4%, respectively (Table 3).

Foliar feeding helps reduce the degree of infection and the development of the disease to a lesser extent. The prevalence of the disease in beans of the Marquise variety is reduced by 11.2% in the filling phase and in the budding phase, remaining almost at the same level as the control. The degree of disease development decreases by 19.2% in the budding phase and by 23.7% in the grain filling phase. On beans of the Kupava variety, the prevalence is 13% and 8.9 in the budding and grain filling phases; development of the disease – 14.3% and 33.8%. On the Strela variety – 7% and 17%; development – 19.7% in the filling phase (Table 3).

**Table 3**  
*Development of root rot of common beans of the Marquise variety depending on the methods of fertilizing, 2023*

Variety	Options	Prevalence,%		Development of the disease,%		efficiency,%	
		budding phase	filling phase	budding phase	filling phase	budding phase	filling phase
Marquise	control	52	60	26,6	35,4	-	-
	NPK	30	43,3	8,3	16,7	68,8	52,8
	foliar fertilizers	50	53,3	21,5	27	19,2	23,7
Kupava	control	69	58,5	16,1	40,2	-	-
	NPK	30	43,3	10	20,0	37,9	50,2
	foliar fertilizers	60	53,3	13,8	26,6	3,8	33,8
Strela	control	43	68,9	19,0	41,7	-	-
	NPK	13	40,0	8,2	21,5	56,8	48,4
	foliar fertilizers	40	56,7	18,8	33,5	1,1	19,7

Thus, the natural fertility of the soil does not allow the full potential productivity of the common bean variety Marquise to be realized, requiring the rational use of fertilizers that increase the yield by influencing the morphological characteristics of plants and increasing disease resistance. The practical application of this aspect of fertilizers, together with the use of biological products in combination, being the task of the planned research, will stabilize the phytosanitary situation in crops, reduce the pesticide load, economic costs and obtain environmentally friendly products of high quality.

**Conclusion.** As a result of research:

- two-year data (2022-2023) were obtained, allowing, under different weather conditions, to determine the contribution of the use of various methods of fertilizing on crop formation and disease resistance of the new common bean variety Marquise and one-year data (2023) for the Kupava and Strela varieties;

- It was revealed that the application of fertilizer N75P50K62 is more effective for the formation of the Marquise bean yield (an increase of 31.3% for Marquise beans; for Kupava beans - 44.3%, Strela -42.9%) than foliar feeding in the phase of 2-3 leaves organomineral fertilizers Ultramag Combi 1 l/ha + Biostim Grain + 1 l/ha + Ultramag Molybdenum 0.5 l/ha; budding and flowering fertilizers Ultramag Combi 1l/ha + Biostim Grain +1l/ha, but if it is impossible to apply fertilizers, the shortfall in yield can be partially compensated for by foliar fertilizing with organomineral fertilizers (10.7% increase for Marquise beans; Kupava -6%, Strela - 7.6%);

- The application of basic fertilizer helps to significantly reduce the prevalence of bean bacteriosis and the degree of disease development. For beans of the Marquise variety, the efficiency of N75P50K62 was 71.4% and 21.2%, 72.2% and 17.0% for the Kupava variety; 68.2% and 21.2% on the Strela variety in the budding and grain filling phases in relation to bacteriosis. Foliar fertilizing with organomineral fertilizers contributes to a lesser extent to reducing the development of diseases: by 9.5% and 9.9% on beans of the Marquis variety; on beans of the Kupava variety - in the budding phase by 5.6%, in the grain filling phase by 13.8%; on Strela beans – by 9.1% and 11.7%, respectively;

- The application of basic fertilizer helps to significantly reduce the development of Fusarium root rot. Efficiency in relation to beans of the Marquise variety is 68.8% and 52.2% in the budding and grain filling phases against bacteriosis; varieties Kupava – 37.9% and 50.2%, respectively; varieties Strela - 56.8% and 48.4%, respectively. The effectiveness of introducing VKU regarding the development of root rot on beans of the Marquise variety was 19.2 and 23.7% in the budding and grain filling phases. For beans of the Kupava variety – 14.3% and 33.8%, respectively. On the Strela variety – 19.7% in the filling phase.

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井底区域处理作为石油集约化生产的方法之一  
**BOTTOM HOLE ZONE TREATMENT AS ONE OF THE METHODS  
OF OIL PRODUCTION INTENSIFICATION**

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注解。在石油生产过程中，石油公司面临着油藏滤滤和水动力性质恶化的问题。为了改善这些性能，使用各种酸和组合物的溶液进行井底区域处理（BHT）。这些工程针对生产井和注入井进行，以提高油井的产能和取水能力。不同的成分允许将这些技术应用于不同类型的地层，因此所进行的 BHT 的有效性很大程度上取决于组件的正确选择。但同时，也有一些技术会在试剂爆炸时产生振动，这也会导致层间流入加剧，从而导致生产过程中出现复杂情况。

关键词：BHZ、化合物、并发症、皮肤因素、过滤特性、反应物质。

**Annotation.** *In the process of oil production, oil companies face the problem of deterioration of the filtration and hydrodynamic properties of the reservoir. To improve these properties, bottom hole zone treatment (BHT) are carried out with solutions of various acids and compositions. These works are carried out both on the producing and injection well stock to increase the productivity and water-intake capacity of wells. Different compositions allow apply these technologies on different types of formations, so that the effectiveness of the conducted BHT largely depends on the correct choice of components. But at the same time, there are also technologies that consist in creating vibrations during the explosion of reagents, which also leads to an intensification of the inflow from the layers with complications arising during the production process.*

**Keywords:** *BHZ, chemical compounds, complications, skin factor, filtration characteristics, reacting substance.*

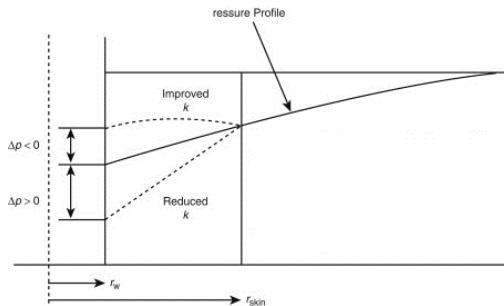
Formation filtration characteristics reduction is possible during the work of wells, especially the contamination of the bottom-hole zone of the formation, which continues throughout the operation period of an oil field. A large drop in pressure characterizes a large disruption in the operation of a well. Thus, the difference between the downhole pressure calculated for a homogeneous radial model and the downhole pressure considering the change in permeability is characterized by a skin factor [1].

Table 1 includes reasons for the bottom hole zone (BHZ) permeability decrease.

**Table 1**  
*Bottom hole zone permeability decrease*

Type of a well	Type of operation	The reason for permeability decrease
Production well	Drilling	Drilling mud penetration and pore channels blocking
		Clays swelling in contact with drilling fluid filtrate
		Incompatibility of injected and reservoir water (chemical decomposition)
	Completion	Sand particles advance to the bottomhole
		Formation compression
		Formation damage caused by deformation
Development	Deviation from the laminar flow	
	Well damage during exploitation	
Injection well	Development	Reservoir colmatage due to the presence of solid particles in the injected water
		Incompatibility of injected and reservoir water
		Clay volume change
		Microcracks formation

It should be taken into an account, that bottom hole zone permeability deterioration is always caused by the influence of several factors. Complete blockage of the fluid inflow into the well is possible in case of pores properties change. Figure 1 shows inflow profile in the bottom hole zone of a contaminated formation.



**Figure 1.** *Inflow profile of the contaminated bottom hole zone*

According to the figure 1 the extent of the skin zone is relatively small compared to the boundaries of the formation. In this case, the inflow profile is curved towards the decrease of the downhole pressure. Thus, additional pressure drops occur in the BHZ which negatively affects the process of oil production.

In order to improve the hydrodynamic properties of the BHZ different measures are being conducted. Thus, a significant decrease in the filtration resistance to the flow of liquid in the production wells by cleaning, leads to the decrease of the skin factor, and this leads to the intensification of oil production, increased reservoir coverage and oil recovery. Currently, a large number of technologies and chemical reagents are applied to conduct BHZ treatment [2].

One of the reagents widely used in the oil industry for the BHZ treatment is hydrochloric acid, which effectively dissolves dolomites and limestones, but it should be taken into an account, that hydrochloric acid is not used in its pure form, because improper use of this reagent can lead to failure of downhole equipment, which will lead to even greater costs. So, special additives are added to the acid solution, such as: water repellents, stabilizers and reaction retarders (acetic acid allows to keep iron salts in a dissolved state and slows the reaction of HCl with the rock, which allows the solution to be injected into deeper areas of the formation), intensifiers (reduce the interfacial tension between the injected solution and oil, which makes it possible to push the reagent deep into the formation and increase the coverage of the formation treatment, which improves the purification of the BHZ from reaction products), corrosion inhibitors (slow down the corrosion of metals) [3].

According to Figure 2, the composition ALDINOL-20 has been actively used on one of the oil production facilities.

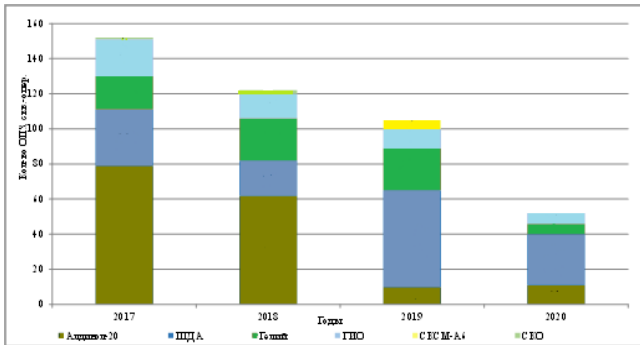


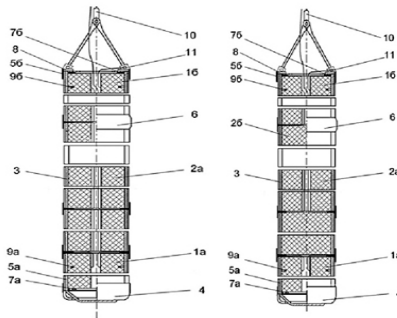
Figure 2. Application of BHZ treatment technologies

One of the reasons for wide use of the “Aldinol-20” composition is that this solution is a mixture of polyatomic alcohols, cationic surfactants, corrosion inhib-

itor, hydrochloric acid and modifying additive “Aldinol-MK”, which comprehensively affects the components of the composition and leads to deeper penetration of the solution into the reservoir. It is worth noting that the composition “Aldinol-20” is designed for production wells treatment in carbonate and low-permeable terrigenous reservoirs with high clay content.

The next technology to be used is “PGDA” - an acoustic powder generator. This technology makes it possible to develop hard-to-recover oil deposits and affect low-permeable layers.

Figure 3 shows the powder pressure generators currently used in the oil industry.



1a, 1b – igniting charges; 2a, 2b – charges with and without a channel; 3 – rope; 4 – tray; 5a, 5b – hoop; 6 – plug; 7a, 7b – lids; 8 – spacers; 9a, 9b – heating elements; 10 – bracket; 11 – clutch

**Figure 3.** Powder generators (89 mm u 112 mm)

The basic principle of this type of processing of BHZ is as follows: during the combustion of PGDA, a rapid and temporary pressure front increase occurs. The increasing rate of the pressure exceeds fracturing pressure of the formation. A network of microcracks forms opposite the perforation interval of the well. The residual combustion product – nitrogen is environmentally friendly, which ensures the environmental safety of the method used. The advantage of the applied method is that the “PGDA” can treat any point in the BHZ, and the efficiency is not worse than standard methods of hydraulic fracturing. It is also worth noting that the cost of the well treatments is low [4].

The next technology for BHZ treatment actions is “Helium”. This technology means injection of the composition consisting of HCl + HF, citric acid, nonionic surfactant into the BHZ. The peculiarity of these treatments is that it is absolutely necessary to conduct swabbing in order to extract reaction products [5].



The next technology “GIO” consists in selective processing of perforation intervals with pulses (0.1-0.15 sec) of high pressure (800-1000 atm.) using a deep well generator, which allows selective treatment in six radial directions.

The following acidic mixture “SKSM-A» allows to treat the BHZ from deposits and coagulants. This mixture is a combustible and consists of hydrochloric and hydrofluoric acids in water and methanol, also the acid mixture is modified with additives to prevent corrosion, salt deposition and emulsion processes.

Table 2 shows a comparison of targeted and factual parameters by years.

**Table 2**  
*Comparison of targeted and factual parameters*

Parameter	2017		2018		2019		2020		2017-2020.	
	proj- ect	fac- tual	proj- ect	fac- tual	proj- ect	fac- tual	proj- ect	fac- tual	proj- ect	fac- tual
Quantity of BHZ treatment, ea.	100	167	120	130	140	98	135	45	530	420
Ad. oil production, th. tonnes	28,9	120	29	58	43	38	50	7,5	160	202

It was revealed, that the carried out BHZ treatment significantly increases additional oil production. This fact means that regular BHZ allow to develop oil fields with less costs.

The decision which BHZ treatment technology should be carried out is based on hydrodynamic, geophysical and other studies, based on data of the filtration properties of a reservoir.

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1961-2020年北高加索地区平均气温和降水规律变化分析  
**ANALYSIS OF CHANGES IN AVERAGE TEMPERATURE AND  
PRECIPITATION REGIME IN THE NORTH CAUCASUS REGION  
FOR THE PERIOD 1961-2020**

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介绍。 本文致力于分析1961-2020年期间北高加索地区平均气温和降水模式的变化。 该研究使用了1961-2020年整个期间北高加索地区各个气候带的季节和年度气温以及降水量的平均数据及其10年平均值。 结果发现,在1961年至2020年的整个观测期间,在北高加索地区境内,年降水量的增加在统计上不显著,而平均气温在统计上显著增加。 2011-2020年是平原、山麓、山区和整个地区四季(除秋季)和全年最热的十年。 在高山地区,2011-2020年十年平均值在春、夏季和全年中最高。 2001年至2010年期间,降水量出现最大正距平,但夏季除外,夏季出现小幅负距平。

关键词: 气候变化、温度状况、降水状况、趋势、北高加索地区。

**Introduction.** *This article is devoted to the analysis of changes in average temperature and precipitation patterns in the North Caucasus region for the period 1961-2020. For the study, averaged data of seasonal and annual temperatures and precipitation amounts in various climatic zones of the North Caucasus region for the entire period 1961-2020 were used and their 10-year averages. It was found that for the entire observation period from 1961 to 2020. On the territory of the North Caucasus region, there was a statistically insignificant increase in annual precipitation against the background of a statistically significant increase in average temperature. Last decade 2011-2020 was the hottest in all seasons (except autumn) and the year as a whole in the plain, foothill, mountain zones and the region as a whole. In the high mountain zone in the period 2011-2020 ten-year average values are maximum in the spring, summer seasons and in the year. The largest positive anomaly in precipitation amounts was observed in the period from 2001 to 2010, with the exception of the summer season, where a small negative anomaly was observed.*

**Keywords:** *climate change, temperature regime, precipitation regime, trend, North Caucasus region.*

The problem of global and regional changes in the environment and climate is now becoming particularly relevant. In the second half of the 20th century, interest in the problem of climate change intensified, when the world meteorological network began to record its warming, which had previously been theoretically predicted by the Russian academician M.I. Budyko [1].

The Climate Change Synthesis Report [2] stated that “Each of the last three decades has experienced higher surface temperatures than any previous decade since 1850. In addition to clear increases over several decades, globally averaged surface temperatures show significant decadal and interannual variability.”

In recent decades, such warming has been observed throughout Russia. Warming is uneven over time; in addition, it manifests itself differently in different regions. The warming effect is strongest at night and during cold seasons, and will be more pronounced in Arctic regions than in the tropics.

The Roshydromet Report for 2021 states that the rate of increase in the average annual temperature across Russia is +0,49°C per decade [3].

Let us analyze changes in average temperature and precipitation patterns in the North Caucasus region, which is rich in diverse natural landscapes and is distinguished by climatic diversity, which have a great influence on the climate of the region. According to climatic conditions, the North Caucasus region is divided into flat (<500 m above sea level), foothill (from 500 to 1000 m above sea level), mountain (> 1000 m above sea level) and high mountain (>2000 m above sea level) climatic zones. Each of these territories is characterized by its own temperature and precipitation regimes [4].

For the study, data from time series of average seasonal and annual temperatures in the surface layer of the atmosphere and atmospheric precipitation for 1961-2020 were used.

The assessment of changes in meteorological parameters was carried out using the regression method and linear regression equations were obtained in the form:

$$y = ax + b, \quad (1)$$

where  $a$  and  $b$  are coefficients that determine the specific form of the linear equation.

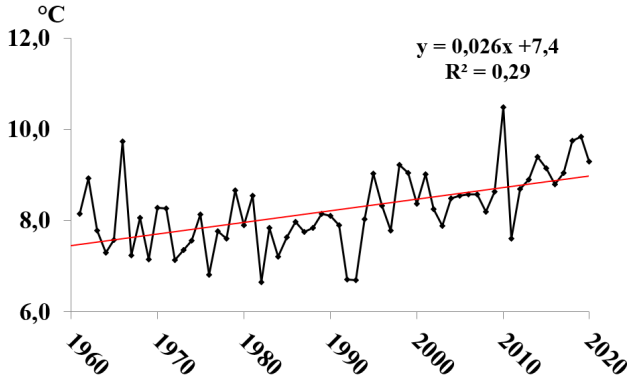
Linear trend coefficients are expressed in degrees per decade, °C/10 years, or in mm/month/10 years (hereinafter referred to as mm/10 years).

The strength of the trend, its statistical significance, was assessed by the value  $D$  (%), the contribution of the trend to the explained variance.

$$D = (R^2) 100\% \quad (2)$$

For the study period 1961-2020. on the territory of the North Caucasus region there was a significant increase in average annual temperatures at a rate of  $0,26^{\circ}\text{C}/10$  years ( $D=29\%$ ) (Fig. 1).

The lowest growth rate was observed in the high mountain zone  $0,1^{\circ}\text{C}/10$  years ( $D=6,0\%$ ), and the highest in the foothill zone  $0,34^{\circ}\text{C}/10$  years ( $D=36,0\%$ ).



**Figure 1.** Average annual temperatures in the North Caucasus region with trend, 1961-2020

Also, interseasonal differences in trends in average annual temperatures in the North Caucasus region have become less noticeable. In all seasons, the trends are positive and statistically significant; the rate of temperature increase ranges from  $0,17^{\circ}\text{C}$  in the autumn season to  $0,38^{\circ}\text{C}$  in the summer season.

A study was conducted of changes in temperature and precipitation regimes in the North Caucasus region in various climatic zones based on 10-year average values in the period 1961-2020.

Table 1 shows that the last decade 2011-2020 was the hottest in all seasons (except autumn) and the year as a whole in the plain, foothill, mountain zones and the region as a whole. In the autumn season, the maximum 10-year average temperatures were observed in the period 2001-2010.

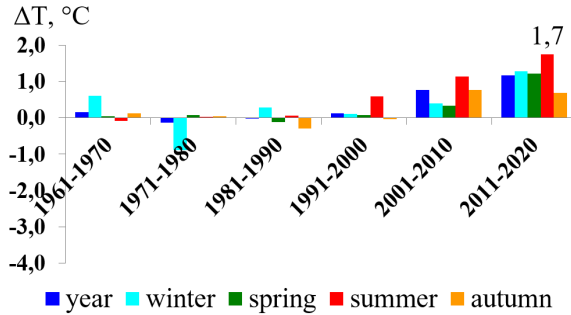
In the high mountain zone in the period 2011-2020 10-year average values are maximum in the spring, summer seasons and in the year. The highest average winter temperature was observed in the period from 1961-1970, and the highest in autumn in the period 1971-1980.

**Table 1**  
*Average ten-year temperatures in various climatic zones  
of the North Caucasus region*

Season	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
<b>Plain zone</b>						
year	11,6	11,2	11,5	11,5	12,4	<b>12,7</b>
winter	0,8	-0,7	0,8	0,4	1,0	<b>1,6</b>
spring	10,3	10,3	10,2	10,4	10,9	<b>11,6</b>
summer	22,7	22,7	22,8	23,2	23,8	<b>24,5</b>
autumn	12,5	12,3	12,3	12,1	<b>13,8</b>	13,2
<b>Foothill zone</b>						
year	9,1	8,8	8,9	9,2	10,1	<b>10,6</b>
winter	-1,6	-2,9	-1,5	-1,7	-0,9	<b>-0,2</b>
spring	8,8	8,8	8,5	8,8	9,3	<b>10,3</b>
summer	19,6	19,6	19,5	20,2	21,0	<b>21,7</b>
autumn	9,8	9,6	9,4	9,5	<b>11,1</b>	10,7
<b>Mountain zone</b>						
year	8,0	7,7	7,8	8,1	8,7	<b>9,0</b>
winter	-0,5	-2,2	-1,1	-1,0	-0,7	<b>0,2</b>
spring	7,5	7,7	7,4	7,7	7,8	<b>8,7</b>
summer	16,5	16,8	16,8	17,4	17,8	<b>18,4</b>
autumn	8,5	8,5	8,1	8,4	<b>9,5</b>	9,1
<b>High mountain zone</b>						
year	2,6	2,5	2,5	2,4	2,6	<b>3,1</b>
winter	<b>-5,7</b>	-7,2	-6,4	-6,7	-7,2	-5,9
spring	1,9	1,8	1,8	1,7	1,6	<b>2,5</b>
summer	10,9	11,0	11,1	11,6	11,9	<b>12,4</b>
autumn	3,5	<b>4,2</b>	3,6	3,2	3,9	3,7
<b>Average values for the North Caucasus region</b>						
year	7,8	7,6	7,7	7,8	8,5	<b>8,9</b>
winter	-1,7	-3,2	-2,1	-2,2	-1,9	<b>-1,1</b>
spring	7,1	7,1	6,9	7,1	7,4	<b>8,3</b>
summer	17,4	17,5	17,6	18,1	18,6	<b>19,2</b>
autumn	8,6	8,6	8,3	8,3	<b>9,6</b>	9,2

Figure 2 shows anomalies of average ten-year temperatures in the North Caucasus region. A temperature anomaly means a discrepancy between indicators and long-term average values (average for 1961-1990). From Figure 2 it is clear that from 2001 to the present, exclusively positive annual and seasonal anomalies have been observed. The period 2011-2020 stands out the most with the highest summer anomaly of 1,7°C. Previous period 1991-2000 had a slight negative anomaly

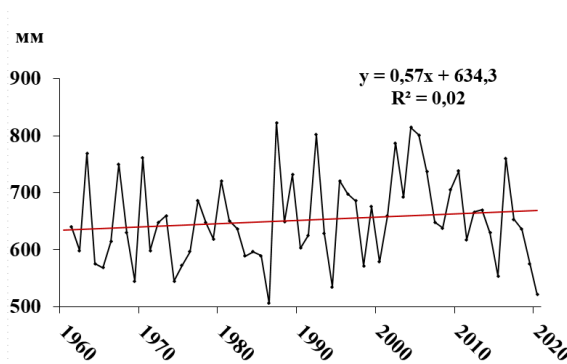
only in the autumn season. During the periods 1961-1970, 1971-1980, 1981-1990 both positive and negative anomalies were observed. The winter anomaly (-0,9°C) was of greatest importance in the period 1971-1980 due to a significant negative anomaly in 1972 (-3,9°C).



**Figure 2.** Anomalies of average ten-year temperatures in the North Caucasus region

The summer season of the last decade also stands out, when the anomaly of the average summer temperature is the largest for the entire observation period (+1,7°).

In the last decade, against the backdrop of an increase in average temperature, a decrease in precipitation amounts was observed throughout the North Caucasus region [5] although over the entire observation period from 1961 to 2020 there was a statistically insignificant increase in annual precipitation at a rate of 5,7 mm/10 years (D=2,0%) (Fig. 3).



**Figure 3.** Average annual precipitation in the North Caucasus region with trend, 1961-2020

Table 2 presents the average ten-year precipitation amounts in various climatic zones and the regional average for the periods 1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010, 2011 -2020.

**Table 2**  
*Average ten-year precipitation amounts in various climatic zones of the North Caucasus region*

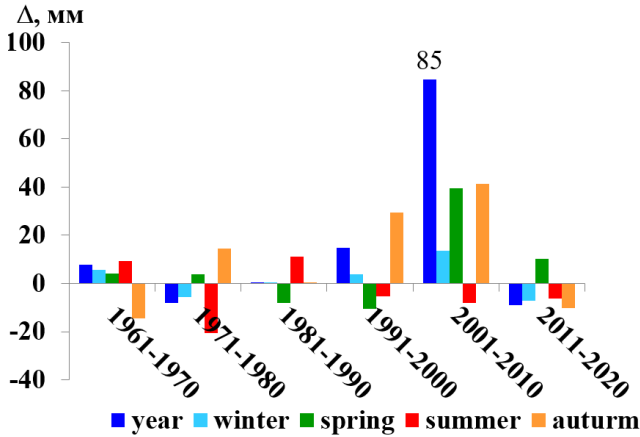
Season	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
<b>Plain zone</b>						
year	413	391	411	428	429	418
winter	82	80	79	83	92	88
spring	101	92	98	100	104	104
summer	131	113	125	110	107	114
autumn	94	108	108	138	125	107
<b>Foothill zone</b>						
year	652	611	633	644	665	617
winter	74	71	70	74	79	73
spring	188	179	174	173	192	201
summer	267	227	265	249	239	234
autumn	120	135	124	145	160	110
<b>Mountain zone</b>						
year	568	581	579	585	666	574
winter	96	88	92	91	105	88
spring	159	170	140	137	202	177
summer	179	162	193	182	179	175
autumn	131	159	156	176	182	134
<b>High mountain zone</b>						
year	947	933	928	951	1128	903
winter	174	139	161	165	185	125
spring	240	245	228	220	331	240
summer	316	272	319	295	299	308
autumn	211	270	227	273	313	222
<b>Average values for the North Caucasus region</b>						
year	645	629	637	652	722	628
winter	106	95	100	104	114	93
spring	172	172	160	157	207	178
summer	223	193	225	209	206	208
autumn	139	168	154	183	195	143

As can be seen from Table 2, the highest precipitation amounts were observed in the high mountain zone, and in the period from 2001-2010. A record precipi-



tation amount of 1128 mm was recorded. Research has shown that in 2001-2010 average annual, average winter and average spring precipitation also had the highest precipitation amounts compared to other periods. The lowest precipitation amounts in all periods were observed in the flat zone.

Figure 4 shows anomalies of average ten-year precipitation amounts in the North Caucasus region.



**Figure 4.** Anomalies of average ten-year precipitation amounts in the North Caucasus region

From Figure 4 it can be seen that the period from 2001 to 2010 is distinguished by the largest positive anomalies of precipitation amounts, with the exception of the summer season, where a small negative anomaly was observed. The average annual anomaly during this period reached 85 mm. Period 1961-1970 had a negative anomaly only in the autumn season. In all periods, both positive and negative anomalies of precipitation amounts were observed.

Anomalies in the periods from 1961 to 2000 are insignificant, and in the period 1981-1990 characterized by the absence of annual, winter and autumn anomalies.

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DOI 10.34660/INF.2023.51.54.173

根据弗拉迪高加索数据气象站的气候特征变化趋势  
**TRENDS IN CHANGES IN CLIMATE CHARACTERISTICS  
ACCORDING TO DATA WEATHER STATION VLADIKAVKAZ**

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抽象的。气候是我们大气中最容易发生变化的特征之一。近十年来,许多气象量的平均季节和年气候特征发生了显著变化。与其他国家相比,它们对俄罗斯的影响更大。

本文的目的是根据位于北奥塞梯共和国(阿拉尼亚)山麓、海拔为 海拔680米。用于比较的气候特征异常是根据两个气候标准计算的:1961-1990年和1991-2020年。

在使用1991-2020年气候常态的研究期间,2022年平均气温出现正异常,而在使用1961-1990年气候常态时。仅观察到负异常。2022年降水量夏秋季节偏少,冬春季节略有增加。

1976-2022年期间,平均十天积雪厚度的增长率下降至-0.11厘米/10年,而1961-2022年期间的增长率为0.13厘米/10年。1973年观测到了创纪录的高积雪异常。

关键词: 温度、降水状况、积雪厚度、气象站、趋势、异常、变化率。

**Abstract.** *Climate is one of the characteristics of our atmosphere that is most susceptible to change. Over the past decade, many average seasonal and annual climatic characteristics of a number of meteorological quantities have changed significantly. They affect Russia to a greater extent than other countries.*

*The purpose of this article is to analyze changes in temperature regimes, precipitation regimes and snow cover thickness for the period 1961-2022 according to the Vladikavkaz weather station, located in the foothills of the Republic of North Ossetia (Alania), at an altitude of 680 m above sea level. Anomalies of climatic characteristics for comparison were calculated for two climatic norms: 1961-1990 and 1991-2020.*

*For the study period using the climate norm for 1991-2020 in 2022, positive anomalies of average temperatures were observed, whereas when using the climate*

*norm for 1961-1990. Only negative anomalies were observed. For precipitation amounts in 2022, there was a deficit in the summer and autumn seasons and a slight increase in winter and spring.*

*During the period 1976-2022 there was a decrease in the growth rate of the average ten-day thickness of snow cover to  $-0.11$  cm/10 years, compared to the period 1961-2022, when the growth rate was  $0.13$  cm/10 years. A record high snow cover anomaly was observed in 1973.*

**Keywords:** *temperature, precipitation regime, snow cover thickness, weather station, trend, anomaly, rate of change.*

Climate change represents one of the main problems of our time. Research confirms that global average temperatures have been rising since the mid-1900s. According to Roshydromet, in Russia the rate of increase in average annual temperature is 2 times higher than on the whole globe, by about  $0.5^{\circ}\text{C}$  per decade. Climate change is manifested not only in an increase in surface air temperature, but also in other climatic characteristics, such as average seasonal precipitation and snow cover [7].

The Roshydromet Report notes that warming is observed throughout Russia in all seasons. The rate of increase in average annual temperature is  $+0.49^{\circ}\text{C}/10$  years, with a contribution to the total variability of 56%. For Russia, 2022 was the 5th year in the descending series of average annual temperatures since 1936 and the anomaly of average annual air temperature was  $0.87^{\circ}\text{C}$  compared to the new climate norm (1991-2020) adopted by the World Meteorological Organization in 2022 year [4].

Previously, the values of the base 30-year period from 1961 to 1990 were used to calculate climate norms; the new norms (average for 1991-2020) are calculated based on more recent data taking into account global warming. The norms are the basis for assessing how daily, monthly and annual climate conditions compare to what is normal for a particular region in today's climate.

This work is a continuation of previous studies on the study of changes in climatic variables in various climatic zones of the North Caucasus region [1, 2], which analyzes the variability of the average long-term characteristics of air temperature in the surface layer, precipitation amounts and snow cover thickness at the Vladikavkaz weather station (North Ossetia - Alanya) for the period 1961-2022.

Time series of meteorological parameters were studied by methods of mathematical statistics and supplemented with linear trends. The linear trend coefficient characterizes the average rate of change of the value under consideration for the entire study period from 1961 to 2022 and for the period from 1976 to 2022. The period since 1976 was chosen conditionally as the beginning of modern warming in accordance with the course of global temperature [3].

Trends were calculated by the well-known least squares method, and the parameters of straight line equations were found that described the variability of the studied quantities [5]. The characteristic of the average rate of change of a climatic variable over the considered period of time is the angular coefficient of the linear trend equation and is expressed when analyzing the temperature regime in degrees per decade ( $^{\circ}\text{C}/10$  years), for the precipitation regime in millimeters/month per decade ( $\text{mm}/10$  years) and for the average ten-day snow depth in centimeters per decade ( $\text{cm}/10$  years).

Over the 62-year period under study, average values, standard deviations, norms and anomalies of average temperatures, precipitation amounts and average ten-day snow cover thickness were obtained. When calculating anomalies, old (1961-1990) and new (1991-2020) climate norms were used.

**Temperature**

Data on annual and seasonal average temperatures, as well as data on changes in temperature conditions at the Vladikavkaz weather station are given in Table 1.

**Table 1.**  
*Temperature regime and anomalies for 1961-2022, Vladikavkaz*

Temperature, $^{\circ}\text{C}$	year	winter	spring	summer	autumn
Average temperature (1961-2022)	9.1	-1.6	9.0	19.5	9.6
Standard deviation	1.1	2.0	1.2	1.4	1.3
Norma (1961-1990)	8.5	-2.4	8.5	18.8	9.1
Average anomaly at the norm1961-1990	0.6	0.8	0.5	0.7	0.5
Norma (1991-2020)	9.7	-0.9	9.4	20.1	10.1
Average anomaly at the norm1991-2020	-0.6	-0.7	-0.4	-0.6	-0.5
Angular coefficient of trend (1961-2022), $^{\circ}\text{C}/10$ years	0.4	0.6	0.3	0.5	0.3
Angular coefficient of trend (1976-2022), $^{\circ}\text{C}/10$ years	0.6	0.7	0.5	0.8	0.5

At the Vladikavkaz weather station, an increase in the rate of increase in average annual and average seasonal temperatures was observed in the period 1976-2022 compared to the period 1961-2022.

The average winter temperature has increased by  $0.6^{\circ}\text{C}/10$  years since 1961, and since 1976 the rate of increase has reached  $0.7^{\circ}\text{C}/10$  years. The rate of increase in spring and autumn temperatures between 1961 and 2022 was  $0.3^{\circ}\text{C}/10$  years, increasing to  $0.5^{\circ}\text{C}/10$  years since 1976. The rate of increase in air temperature in the summer season at these time periods is the greatest and is equal to  $0.5^{\circ}\text{C}/10$  years and  $0.8^{\circ}\text{C}/10$  years, respectively. The rate of increase in average annual temperatures between 1961 and 2022 was  $0.4^{\circ}\text{C}/10$  years and has increased to  $0.6^{\circ}\text{C}/10$  years since 1976.

When analyzing average temperatures for the period 1961-2022 when using the climate norm for 1961-1990 anomalies have positive values. Taking into account the climate norm 1991-2020 all anomalies have a negative value.

Figure 1 shows the average annual temperature anomalies for the period 1961-2022, relative to the old norm (1961-1990) (Fig. 1a) and the new norm (1991-2020) (Fig. 1b).

Figure 1b shows that, despite the fact that the average anomaly (at the 1991-2020 norm) has a negative value and the number of positive anomalies is less than negative ones (25:37), since 2012 exclusively positive anomalies of average annual temperatures have been observed. When analyzing anomalies using the climate norm for the period 1961-1990 (Fig. 1a) exclusively positive anomalies have been observed since 1994 and the number of positive anomalies is more than 2 times greater than negative ones (44:18). The largest anomaly in average annual temperature was observed in 2010.

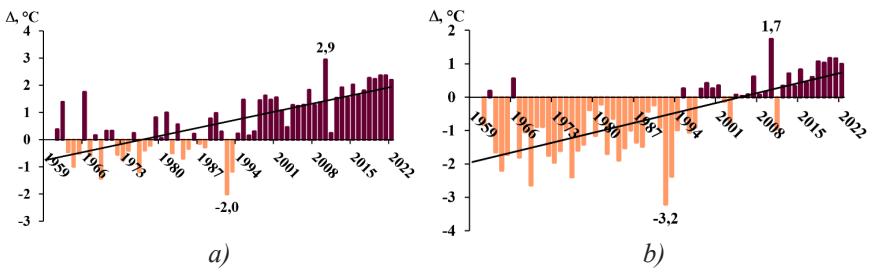


Figure 1. Annual mean temperature anomalies, 1961-2022

A study of seasonal and annual temperature anomalies for 2022 showed that in all seasons and in the year at the Vladikavkaz m/station positive anomalies of average temperatures were observed, with the exception of the spring season (-0.7°C). The winter anomaly is in the lead, followed by the autumn and summer anomalies (Fig. 2).

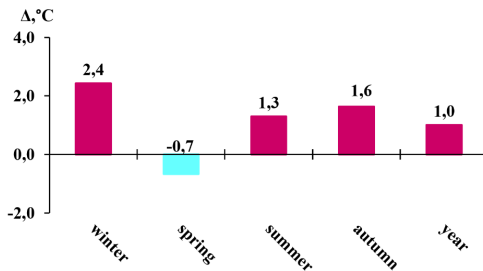


Figure 2. Seasonal average temperature anomalies, 2022

**Precipitation regime**

Average value of the average annual precipitation for 1961-2022 at the Vladikavkaz metro station it is 930 mm while the norm is 954 mm. The maximum amount of precipitation occurs in the summer season - 379 mm, followed by the spring (290 mm), autumn (170 mm) and winter (91 mm) seasons (Table 2).

During the period from 1961 to 2022, there was a positive trend in annual precipitation (1.1 mm/10 years), with a further increase (6.6 mm/10 years) in the period 1976-2022. Spring precipitation also showed a positive trend of 6.2 mm/10 years since 1961, further increasing to 11.2 mm/10 years since 1976, while summer and autumn precipitation became negative.

As in the case of average temperature anomalies in all seasons and the year as a whole, average precipitation anomalies are negative when using the new 1991-2020 norm and positive at the norm of 1961-1990.

**Table 2.**

*Precipitation regime and anomalies for 1961-2022, Vladikavkaz*

<b>Precipitation, mm</b>	<b>year</b>	<b>winter</b>	<b>spring</b>	<b>summer</b>	<b>autumn</b>
Total precipitation (1961-2022)	930	91	290	379	170
Standard deviation	173	34	74	109	57
Norma (1961-1990)	87	279	376	166	909
Average anomaly at the norm1961-1990	3.7	11.3	1.6	3.8	19.6
Norma (1991-2020)	954	95	304	383	172
Average anomaly at the norm1991-2020	-25.4	-4.3	-13.7	-5.4	-3.2
Angular coefficient of trend (1961-2022), mm/ 10 years	1.1	1.5	6.2	-2.6	-3.3
Angular coefficient of trend (1976-2022), mm/ 10 years	6.6	1.2	11.2	-2.3	-3.0

The analysis of anomalies of annual precipitation for the period from 1961 to 2022 was carried out showed that the number of positive and negative anomalies for the entire study period under the climatic norm of 1961-1990 were distributed approximately equally: 30 positive and 32 negative anomalies (Fig. 3a). When analyzing anomalies using the climate norm for the period 1991-2020 (Fig. 3b) the number of positive anomalies is less than negative ones (23:39). A record high positive anomaly was observed in 1967, and a negative one in 1986 (Fig. 3).

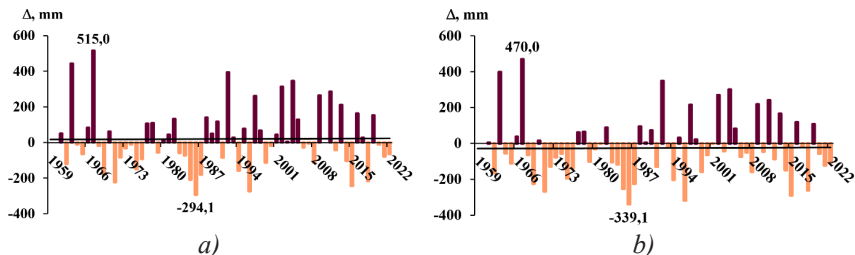


Figure 3. Annual precipitation anomalies, 1961-2022

The trend line throughout the entire observation period (Fig. 3) indicates the stability of annual precipitation amounts.

An analysis of anomalies of seasonal and annual precipitation amounts for 2022 showed that this year there was a deficit of precipitation amounts in the year, the summer and autumn seasons. In the winter and spring seasons there was a slight positive anomaly (Fig. 4).

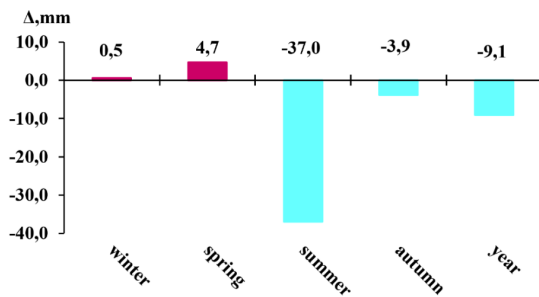


Figure 4. Seasonal anomalies of precipitation amounts, 2022

### Snow cover

The state of snow cover is as important a characteristic of the regional climate as temperature and precipitation. Observations of snow cover begin in the autumn from the moment the first (temporary) snow cover appears and continue until its complete disappearance in the spring. To characterize the average ten-day snow depth, its average values are calculated over ten-day months of the cold season [6].

An analysis of observations of the snow cover thickness regime was carried out for the period 1960/1961 until 2021/2022 Seasons from October to April 1960/1961, 1961/1962,..., 2021/2022 for brevity they are written as 1961, 1962,..., 2022. When analyzing the characteristics of snow cover, for example, 1961, data from October, November, December 1960 and January, February, March and April 1961 were used. Table 3 presents statistical characteristics of snow cover thickness.

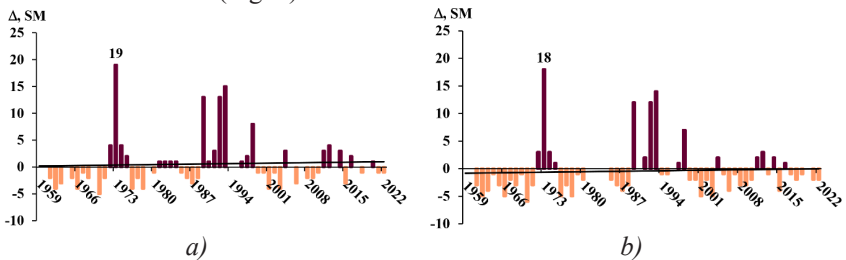


**Table 3.**  
*Snow cover regime and anomalies for 1961-2022*

Snow cover, cm	year
Snow depth (1961-2022)	7.0
Standard deviation	5.0
Norma (1961-1990)	6.0
Average anomaly compared to the 1961-1990 norm	0.6
Norma (1991-2020)	7.0
Average anomaly at the norm 1991-2020	-0.4
Angular coefficient of trend (1961-2022). cm/10 years	0.13
Angular coefficient of trend (1976-2022). cm/ 10 years	-0.11

As can be seen from the calculation results there has been a decrease in the growth rate of the average ten-day thickness of snow cover from 0.13 cm/10 years to -0.11 cm/10 years since 1976. The average value of the average ten-day snow cover thickness was 7.0 cm. which coincides with the climate norm (1991-2020 average) and is 1 cm higher than the previously used climate norm.

Over the studied period, the ratio of positive and negative anomalies is approximately the same (32:30) when using the 1961-1990 climate norm (Fig. 5a) and (30:32) with the climate norm for 1991-2020 (Fig. 5b). A record high anomaly was observed in 1973 (Fig. 5).



**Figure 5.** Annual snow depth anomalies. 1961-2022

The variation in snow cover thickness during the observation period at the Vladikavkaz foothill station ranges from 1.0 cm (1970) to 25.0 cm (1973), with a long-term average value of 7.0 cm.

Figure 6 shows anomalies of the average ten-day snow cover thickness for the months of the cold period 2021-2022 which showed that a positive anomaly was observed only in January and amounted to 1.5 cm. and all other months of the cold season anomalies had negative values from -1.0 cm in October to -6.1 cm in February.

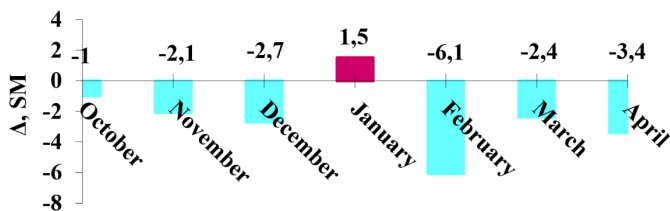


Figure 6. Snow thickness anomalies by month, 2022

Table 4 presents the average values of the average ten-day snow cover thickness for the months of the cold season of the period 1961-2022.

Table 4.

Average ten-day snow cover thickness

Months	October	November	December	January	February	March	April
Average ten-day snow thickness	1.2	3.4	5.6	7.4	8.4	4.8	2.4

Studies on the distribution of the average ten-day thickness of snow cover over the study period showed that the highest averaged value at the Vladikavkaz m/station was obtained in February - 8.4 cm and January - 7.4 cm.

Based on the results of the study, it was found that at the Vladikavkaz metro station there was an increase in the rate of increase in average annual temperatures from 0.4°C/10 years in the period 1961-2022 up to 0.6°C/10 years in the period 1976-2022. The number of positive anomalies is less than negative ones. Exceptionally positive anomalies of average annual temperatures in Vladikavkaz were observed using the old climate norm since 1994, and with the new climate norm since 2012. When analyzing average temperatures using the 1991-2020 climate norm in 2022 their positive anomalies were observed in all seasons and in the year, with the exception of spring.

There was a positive trend in annual precipitation of 1.1 mm/10 years with its further intensification to 6.6 mm/10 years in the period 1976-2022. In 2022, there was a deficit in precipitation amounts in the summer and autumn seasons and a slight increase in winter and spring. In contrast to the average temperature for precipitation amounts throughout the entire observation period, the trend line indicates the stability of annual precipitation amounts.

There was a decrease in the growth rate of average ten-day snow cover thickness from 0.13 cm/10 years in the period 1961-2022 to -0.11 cm/10 years since 1976. A record high snow cover anomaly was observed in 1973.

With the transition to new climate norms, which are calculated on the basis of more recent data (1991-2020) taking into account global warming, the anomalous values of climate characteristics have noticeably decreased.

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