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ИНСТИТУТ ЭКОНОМИКИ И УПРАВЛЕНИЯ АПК

ЕДИНСТВО В МНОГООБРАЗИИ: ДИАЛОГ ЯЗЫКОВ И КУЛЬТУР

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Издание представляет интерес для широкой аудитории читателей, заинтересованных в обсуждении актуальных проблем современной лингвистики, межкультурной коммуникации и инновационного опыта преподавания иностранных языков для их практического применения в естественных, технических и гуманитарных отраслях научного знания, выявлению перспектив их разрешения.

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РАЗДЕЛ 3. ИНОСТРАННЫЙ ЯЗЫК В ПРОФЕССИОНАЛЬНОЙ КОММУНИКАЦИИ: ЕСТЕСТВЕННО-ТЕХНИЧЕСКИЕ НАУКИ

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FOREIGN LANGUAGE IN PROFESSIONAL COMMUNICATION: NATURAL SCIENCES

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Abstract: This study examines how English functions as a tool for professional interaction in natural science and engineering contexts. The authors draw a clear line between everyday language skills and specialised language proficiency (LSP). Among the critical competencies identified for successful cross-cultural technical communication are precise use of terminology, understanding of academic genres, and strategic discourse abilities. The paper highlights genre and stylistic characteristics typical of research papers, patents, technical guides, and spoken presentations. Methodological recommendations are provided for building foreign-language professional competence among students pursuing non-linguistic degrees.

Keywords: professional communication, English for specific purposes (ESP), natural and technical sciences, technical translation, academic writing skills, intercultural competence.

ИНОСТРАННЫЙ ЯЗЫК В ПРОФЕССИОНАЛЬНОМ ОБЩЕНИИ: ЕСТЕСТВЕННЫЕ НАУКИ

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Аннотация: В данном исследовании рассматривается, как английский язык функционирует в качестве инструмента профессионального взаимодействия в области

естественных наук и инженерных дисциплин. Авторы проводят чёткое различие между повседневными языковыми навыками и специализированной языковой компетенцией (LSP). Среди ключевых компетенций, необходимых для успешной межкультурной технической коммуникации, выделяются: точное использование терминологии, понимание академических жанров и стратегические дискурсивные способности. В статье освещаются жанрово-стилистические характеристики, типичные для научных статей, патентов, технических руководств и устных презентаций. Предлагаются методические рекомендации по формированию иноязычной профессиональной компетенции у студентов неязыковых направлений подготовки.

Ключевые слова: профессиональная коммуникация, английский для специальных целей (ESP), естественные и технические науки, технический перевод, навыки академического письма, межкультурная компетенция.

Introduction

The ever-increasing globalisation of scientific and technical knowledge has turned foreign language ability from a nice-to-have extra into a core career necessity. For specialists working in natural and technical fields, English serves as a lingua franca – a universal means of sharing research findings, taking part in international collaborations, publishing in respected journals, and supporting technology exchange.

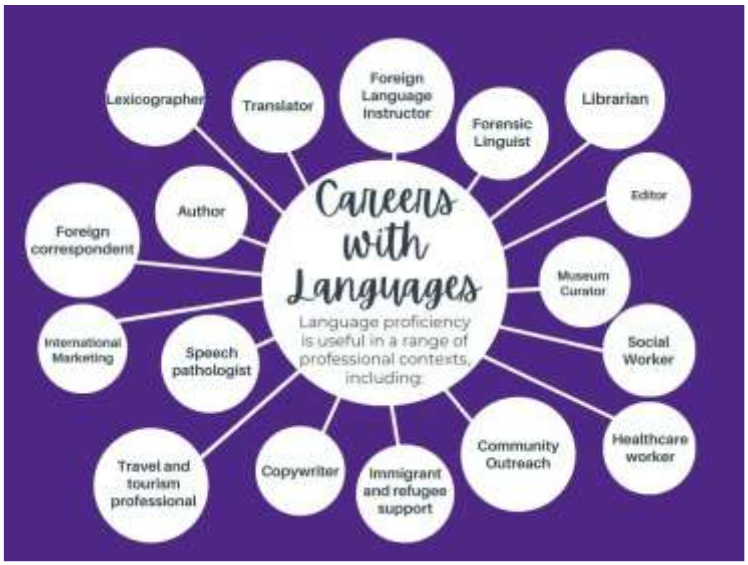

Figure 1. Professional contexts of language proficiency.

At the same time, traditional university language teaching – which tends to focus on general topics and common vocabulary – does not prepare future engineers and researchers for real professional communication. There is often a considerable gap between what students know passively (grammar and words at the B1–B2 level) and what they actually need to do in their jobs, for example writing summaries, joining in expert discussions, or making sense of equipment instructions [9].

The goal of this paper is to describe the specific nature of foreign-language professional communication in the natural and technical sciences and to suggest practical ways of developing the relevant competencies.

1. Professional communication as a distinct discourse type Professional exchange in the natural and technical sciences falls under the category of institutional discourse. This type is defined by several key features:

2. Purpose: delivering accurate, verifiable, and repeatable data.

3. Participants: experts at different stages of their careers – from researchers and product developers to technologists and clients.

4. Medium: written formats (manuscripts, technical reports, product specifications) and spoken formats (conference talks, thesis defences, project reviews).

5. Language characteristics: strict use of terminology, neutral tone, and predictable grammatical structures.

In contrast to humanities discourse, where multiple interpretations and stylistic variation are often accepted, natural-technical discourse leans heavily on nouns. Terms can account for as much as a quarter to nearly a third of all words in a given text [10; 11]. In addition, one frequently encounters passive voice, subjectless sentences, and extended noun modifiers – for instance, laser-induced fluorescence spectroscopy system.

Core elements of foreign-language professional competence for specialists

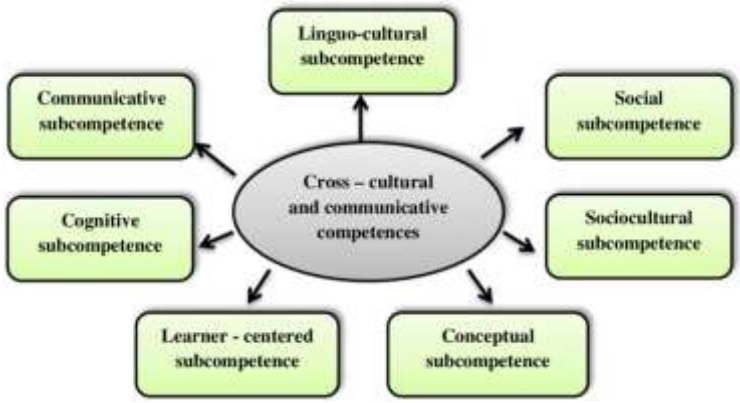

Figure 2. Cross-cultural and communicative competences.

Drawing on professional standards from fields such as engineering, biotechnology, and applied mathematics, as well as on requirements from international exams (IELTS Academic, TOEIC, TELC Technical), the following sub-competencies stand out:

1. Lexico-terminological competence: a solid grasp of specialised terminology in one's own discipline (at least 2000–2500 actively used items), plus familiarity with international scientific vocabulary and common abbreviations (e.g., CAD/CAM, HPLC, CFD).

2. Genre-textual competence: the skill to both produce and understand standard document types – these include IMRaD-structured research papers, patent applications, technical requirement documents, abstracts, and professional biographies.

3. Discursive-strategic competence: appropriate use of ready-made phrases for agreeing, disagreeing, asking for clarification, or raising a polite objection during academic discussions.

4. Translational competence: not literary translation, but rather referential transfer of technical terms, equations, method labels, and instrument names from one language to another.

5. Compensatory competence: the ability to rephrase a difficult technical idea when the exact foreign-language equivalent is not readily available.

Handling natural-technical texts: empirical observations

Figure 3. Scientific observation.

An empirical investigation conducted at the Department of Foreign Languages, Faculty of Engineering (sample: 87 second- and third-year students majoring in Applied Mechanics and Bioengineering) revealed typical difficulties:

Polysemy of common words: cell may denote a biological cell, prison cell, electrical cell, or camera depending on context.

Syntactic compression: participial and gerundial phrases, multi-word modifiers (e.g., the newly developed temperature-controlled high-pressure reactor).

Listening cognitive load: comprehending lectures or presentations in a foreign language demands not only linguistic but also subject-matter knowledge.

Effective instructional techniques included abstracting (summarizing content using core vocabulary) and paraphrasing terminological clusters.

Practical guidelines for university curricula

Drawing on the findings, the following principles for designing an "English for Professional Communication" course in natural-technical fields are proposed:

1. Authenticity principle: utilizing genuine texts (e.g., Nature, Engineering, IEEE Transactions) rather than simplified instructional materials.

2. Interdisciplinary coordination: aligning language class topics with specialized course content (e.g., thermodynamics → experiment description → conclusion writing).

3. Productivity principle: active speech practice (simulations such as "international lab meeting" or "grant proposal discussion") should occupy at least 40% of class time.

4. Bilingual modeling: alternating use of native and target languages to highlight differences in expressing identical scientific ideas. Implementation: modular structure (vocabulary → reading → writing → speaking → project), cumulative term banks, and use of corpus tools (e.g., AntConc) for collocation analysis.

5. Future directionsAdvances in artificial intelligence and machine translation do not diminish but rather intensify the need for professional foreign-language competence. Automated systems (DeepL, ChatGPT) produce critical errors when translating ambiguous terms, fail to distinguish patents from reviews, and ignore journal-specific stylistic conventions. Hence, the future professional must act not as a passive recipient but as an editor and verifier of machine-generated translations. Furthermore, training in open science genres (preprints, data journals, public peer reviews) and international scientific communication ethics (authorship, conflict of interest, plagiarism) is gaining relevance.

Thus, a foreign language acts for specialists of a natural-technical profile not as a scattered set of clichés, but as a systemic means of scientific knowledge and communication. Effective preparation involves the transition from abstract language learning to mastering a subject-oriented language based on real communicative scenarios. The proposed approaches are universal for engineering and natural sciences, but their implementation requires the integration of the efforts of foreign language teachers and specialized departments.

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CLASSIFICATION OF THE AQUATIC ECOSYSTEM SERVICES

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Abstract: the concept of ecosystem services provides an approach to establishing human relationship with nature while offering justification for the conservation and restoration of natural ecosystems. Aquatic ecosystems such as rivers, lakes, and groundwater deliver essential services including water supply, recreation, and fishery. In addition, services linked to the hydrological cycle of river basins, namely water purification, water retention, and climate regulation, are of critical importance. Despite the growing interest in this topic, it was difficult to apply it to water resources management without practical definitions and methodologies. In this article, the authors propose the classification of aquatic ecosystem services based on the analysis of widely used frameworks (R. Costanza, MEA, TEEB, CICES).

Keywords: ecosystem services, natural resources, aquatic ecosystem services, classification of ecosystem services.

КЛАССИФИКАЦИЯ ВОДНЫХ ЭКОСИСТЕМНЫХ УСЛУГ

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Аннотация: концепция экосистемных услуг позволяет выстроить взаимосвязь человека с природой и служит обоснованием для сохранения и восстановления природных экосистем. Водные экосистемы (реки, озёра, подземные воды) предоставляют такие важнейшие услуги, как водоснабжение, рекреация и рыболовство. Особое значение при этом имеют услуги, связанные с гидрологическим циклом речных бассейнов: очистка воды, водоудержание и регулирование климата. Несмотря на растущий интерес к данной теме, отсутствие чётких определений и методик долгое время затрудняло применение этой

концепции в управлении водными ресурсами. В настоящей статье авторы на основе анализа широко используемых классификаций (Р. Костанца, MEA, TEEB, CICES) предлагают собственную классификацию экосистемных услуг водных объектов.

Ключевые слова: экосистемные услуги, природные ресурсы, экосистемные услуги водных объектов, классификация экосистемных услуг.

The concept of ecosystem services emerged in the 1960s and 1970s, driven by a combination of scientific, socioeconomic, and environmental factors [7]. The 1972 United Nations Conference on the Human Environment in Stockholm was the first world conference to make the environment a major issue [2]. One important event was the Ramsar Convention on Wetlands of International Importance, signed in 1971. It was based on the idea that humans and the environment depend on each other, and it acknowledged the vital functions of wetlands: controlling water cycles and supporting local wildlife and plants.

The 1977 UN Water Conference in Mar del Plata, Argentina, was a landmark event, as it was the first-time access to clean drinking water was recognized as a fundamental human right.

The term “ecosystem services” was first introduced in 1981 by P. Ehrlich and A. Ehrlich [6], highlighting the social importance of nature’s functions. In ecology, the term “ecosystem function” has traditionally been used to describe the range of ecosystem processes occurring within a system [9].

In the 1990s, ecosystem services became the prevailing focus in the scientific literature on environmentalism, and interest in methods for estimating their economic value grew as well [7].

There are currently a lot of active researches and discussions on how to bring the concept of ecosystem services into water resource management. In January 2025, the United Nations University Institute for Water, Environment and Health (UNU-INWEH) published a report called “Global Water Bankruptcy: Living Beyond Our Hydrological Means in a Post-Crisis Era”. Its author, K. Madani, uses the idea of water bankruptcy as a metaphor drawn from finance: bankruptcy happens when debts become so large that you can no longer meet your obligations. Water is treated as a form of natural capital, with the renewable sources acting like a checking account and non-renewable ones (such as glaciers and wetlands) like a savings account. Water bankruptcy is defined as a long-term breakdown in the human-water relationship, where water use exceeds safe levels. This leads to damaged ecosystems and high costs for recovery. These points highlight the need for a classification of aquatic ecosystem services that could serve as a practical tool for tracking and managing natural capital.

Despite growing interest, applying this concept to water resource management is difficult because there is no widely accepted, unified classification. This is due to differences in research scales and varying definitions of the term “ecosystem services” [3, 10, 11].

Existing classifications (Costanza et al., 1997; MEA, 2005; TEEB, 2010; CICES, 2013) were developed for different purposes and are not always suited to the specific characteristics of aquatic ecosystems.

The first widely used classification of ecosystem services is the one proposed in the article on the value of the world's ecosystem services [7], published in the journal Nature. The authors identified 17 types of ecosystem functions, grouped by ecosystem type. For the entire biosphere, they estimated that ecosystems provide at least US$33 billion worth of services annually. According to R. Costanza, the largest contribution comes from nutrient cycling (US$17 billion). A significant portion of the estimated value comes from services currently outside the market system, such as waste treatment (US$2.3 billion), disturbance regulation (US$1.8 billion), and gas regulation (US$1.3 billion).

In the Millennium Ecosystem Assessment (MEA), ecosystem services were categorized into four types: provisioning, regulating, cultural, and supporting.

In the summary report of the MEA, prepared to ensure compliance by the contracting parties to the Convention on Wetlands (Ramsar, Iran, 1971), the ecosystem services of wetland ecosystems were categorized as follows:

- Provisioning services (food, drinking water, materials and fuel, biochemicals, genetic materials);
- Regulating services (climate regulation, water regulation, water purification and waste removal, erosion regulation, natural hazard regulation, pollination);
- Cultural services (spiritual, cultural and recreational, aesthetic, educational);
- Supporting services (soil formation, nutrient cycling).

Due to the significant role of the water cycle in the planet's climatic, chemical, and biological processes, it is difficult to classify it unambiguously as a supporting, regulating, or provisioning service. Atmospheric precipitation in the form of rain or snow is the ultimate source of water that sustains ecosystems. In turn, ecosystems determine the nature of renewable freshwater resources for human well-being by regulating the distribution of precipitation among evaporation, recharge, and runoff processes [4, 5].

The TEEB classification includes similar categories, but instead of supporting services, a different category was introduced – habitat services. In TEEB Russia, three main groups are distinguished – production, environment-forming, and information services, along with a group of recreational services that are complex in nature and depend on the ecosystem functions of all three preceding groups.

As research practices deepened, the limitations of the "flat" (non-hierarchical) structure and classifications of MEA and TEEB became apparent:

1. Risk of double counting;
2. Blurred boundaries between intermediate and final services;
3. Terminological diversity;
4. Lack of hierarchy.

In the CICES cascade model, three main groups of ecosystem services are distinguished: provisioning, regulating & maintenance, and cultural. Thus, maintenance services were combined into one group with regulating services.

It is also worth noting that the developers of CICES do not distinguish a separate group of supporting services, since the main task was to identify the "final" products of ecosystems that could serve as a basis for assessment and analysis. Moreover, because many ecosystem services can be considered in one case as a final service and in another as an intermediate one, there is a risk of double counting. Therefore, the responsibility for avoiding double counting lies with the user of the classification and the purposes for which it is used – not only with its developer [2].

CICES uses the following levels: Section – Division – Group – Class – Class Type. The first four levels are universal; the fifth can be adapted to specific ecosystems or regions, which provides flexibility while maintaining comparability [4]. Thus, the hierarchical CICES model, designed for accounting purposes, was an attempt to reconcile previous versions of classifications.

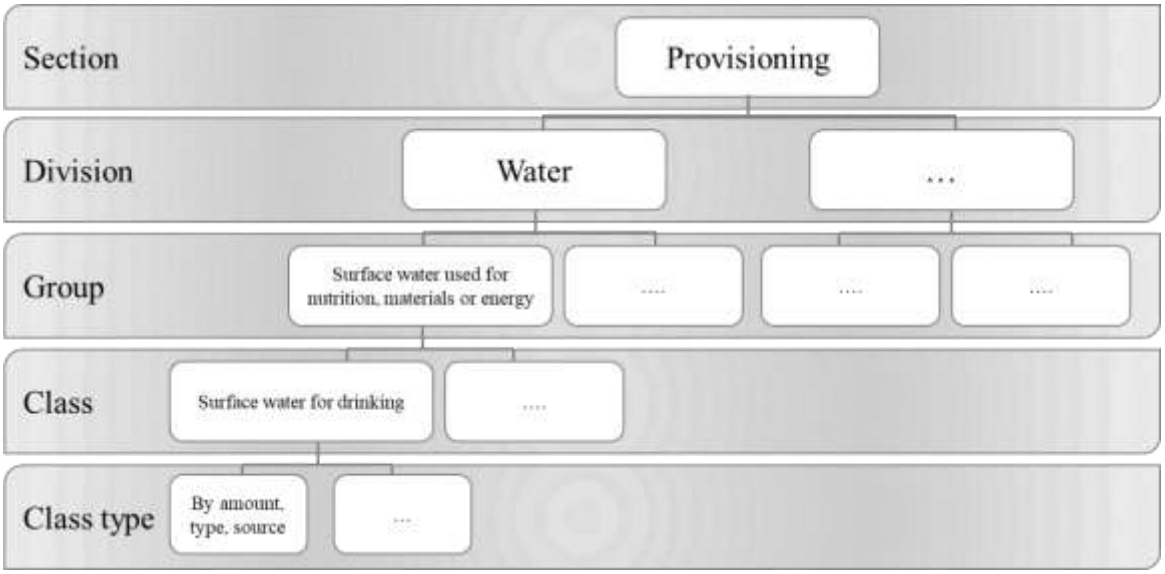

Figure 1. CICES v. 5.1 classification scheme using the example of a water supporting service.

Using the logic of the CICES classification and building upon previous classifications (R. Costanza, MEA, TEEB), the authors propose a classification expanded for aquatic ecosystems (Table 1). The proposed classification focuses on final services. Supporting services were separated into a distinct category to minimize the risk of double counting in the assessment.

Table 1. Classification of ecosystem services detailed for aquatic ecosystems.

Category	Section	Class - final service
Provisioning	Aquatic bioresources	Fisheries
		Harvesting of aquatic invertebrates and algae
	Water supply	Drinking water supply from surface sources

Category	Section	Class - final service
		Drinking water supply from groundwater sources
		Water supply for irrigation
		Water supply for industry
	Raw materials	Biological raw materials
		Mineral raw materials
	Genetic resources	Conservation and use of the gene pool of valuable species
	Water flow regulation	Floodwater retention - flood risk reduction
		River baseflow maintenance
		Water quality regulation and self-purification process
	Biological filtration	Nutrient removal – nitrogen, phosphorus
	Climate regulation – local	Influence of large water bodies and wetlands on humidity and temperature
	Erosion prevention	Bank stabilization by root systems –aquatic vegetation, riparian forests
Cultural	Recreation and tourism	Ecotourism in protected water areas
		Active water recreation
		Health and wellness tourism
	Aesthetic and spiritual value	Preservation of unique water landscapes
		Objects of cultural and spiritual heritage
	Education and science	Use of water bodies in environmental education
		Scientific research
Supporting	Nitrogen and phosphorus cycling	X
	Sediment formation	X
	Fish migration	X

At the same time, there are limitations to the proposed classification:

- Lack of data for quantitative assessment (absence of continuous monitoring);
- The category of the water body is not taken into account;
- The location of the water body is not considered;
- Difficulty in assessing transboundary water bodies;
- Ignoring negative services (dis-services);

Legal constraints, which create uncertainty when attempting to use the classification as a basis for management decisions or payment mechanisms [1].

Thus, the difficulty of applying the ecosystem services concept to water bodies is not related to the idea itself, but to the lack of unified approaches to their description and measurement. Existing classifications either insufficiently detail aquatic ecosystem services or leave the risk of double counting when distinguishing between services and benefits. The proposed classification of aquatic ecosystem services allows for the systematization of existing approaches, the elimination of ambiguity, and the creation of a basis for their assessment and for making management decisions.

Further work involves developing recommendations for using the classification for environmental protection and water body conservation, as well as in payment for ecosystem services systems.

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ANALYZING THE INFLUENCE OF V.P. GORYACHKIN'S CONTRIBUTION TO AGRICULTURAL AND ENGINEERING SCIENCE AND PRACTICE

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Abstract: The paper evaluates V.P. Goryachkin's contribution to agriculture and engineering. The research considers the relationship between V.P. Goryachkin's scientific and practical contribution to Russia's Agro-industrial sector operation. The paper evaluates the scientist's contribution from the interdisciplinary approach positions. The research enables to make reasoned conclusions about the scientist's personality traits, based on bibliographic discoveries. The questionnaire developed dedicated to V.P. Goryachkin's life and work, contains the questions divided into three blocks. The paper analyzes the relationship between the students' knowledge about V.P. Goryachkin's life and work and the motivation level to obtaining this knowledge.

Keywords: V.P. Goryachkin, engineering education, science, practice, agriculture, technique.

АНАЛИЗ ВЛИЯНИЯ ВКЛАДА В.П. ГОРЯЧКИНА В СЕЛЬСКОХОЗЯЙСТВЕННУЮ И ТЕХНИЧЕСКУЮ НАУКУ И ПРАКТИКУ

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Аннотация: В данной работе оценивается вклад В.П. Горячкина в сельское хозяйство и инженерию. Рассматриваются взаимоотношения научного и практического вклада В.П. Горячкина в функционирование агропромышленного сектора России. Вклад учёного оценивается с позиций междисциплинарного подхода. На основании библиографических сведений делаются аргументированные выводы об особенностях личности учёного.

Разработанный опросник, посвящённый жизни и деятельности В.П. Горячкина, содержит вопросы, разделённые на три блока. Анализируется соотношение между знаниями студентов о жизни и работе В.П. Горячкина и уровнем мотивации их получить. Анализируется значение трудов В.П. Горячкина на разных уровнях – практическом, научном, государственном, образовательном.

Ключевые слова: В.П. Горячкин, инженерное образование, наука, практика сельское хозяйство, техника.

Relevance. Our topic is of great relevance, because being multidimensional, this topic deals with the problematics of disciplines belonging to different groups, such as scientific, technical and humanitarian ones.

The first aspect is scientific. On the one hand, science, in general, is known as "the knowledge area, characterized by its own theory" [1, p.33]. It means that each science has got its own purpose and tasks, subject and object, methods.

Scientific contribution is termed as the proportion existing between the outcome level and utility [3, p.292]. Therefore, scientific contribution is great, provided many things have been done, and they are of great use.

On the other hand, being "the other side of the coin", practice is termed as "the material goal-oriented human activity" [6, p.523], unlike science that can be characterized as spiritual activity. This definition demonstrates that practice is based on science and its ideas, both phenomena being considered within gnoseology.

Being close to natural science concept, agriculture can be characterized as "human life activity foundation, producing food, providing raw materials for industry and contributing to biodiversity maintenance" [7, p.184]. This definition attracts us by the fact that science has been highly appreciated in it. And besides, being comprehensive, this definition includes the agriculture role in producing both edible and non-edible things and its dependence on natural resources.

The second aspect of our research is technical. Engineering can be viewed as "the scientific knowledge material embodiment" [4, p.159]. We are inspired by this definition, as it manages to combine the ideas of science, practice and engineering in one concept.

The third aspect is humanitarian. The first psychological idea that is of importance for our research is a personality, because V.P. Goryachkin is known as a famous person. There are a lot of definitions formulated about a personality. We were interested by the definition according to which a personality is termed as the number of traits which the person's individuality is based on [5, p.460]. This definition is of interest for us as it emphasizes the person's individuality that is his talent foundation, and V.P. Goryachkin can be characterized as a gifty personality.

The second psychological idea which we are interested in is the term "influence" that can be understood as a successful, efficient and productive impact" [2, p.193]. As a result, we can understand the positive traits of the term "influence".

The research purpose, subject, object and tasks Our research purpose is to analyse the influence of V.P. Goryachkin's contribution as the research subject on both

agriculture and farm machinery development as objects. The research tasks are to: 1) classify the basic definitions to agriculture, engineering and personality; 2) analyze the factors influencing human personality, in general and V.P. Gorachkin's personality, in particular; 3) consider and evaluate V.P. Gorachkin's output to technical achievements, modifications and inventions; 4) prove V.P. Gorachkin's ideas importance nowadays.

The research problems. The first problem that has to be solved in our research is there is little scientific history knowledge about this time period. The analysis difficulty is that this period lasted from the end of the 19th century to the middle of the 20th century, that were quite different historical periods. The second problem is it is difficult to analyze the personality's contribution, provided you are not an eyewitness of his life and the events he has participated in. As a result, only documents are available for your analysis.

The research methods. We have applied analytical and mathematical methods as well as a survey in our research.

The research theoretical part. Firstly, we have found out the factors influencing the personality development. We have divided these factors into two groups. The first group includes the factors that are closer to the individual person. The first factor belonging to this group is background. The first aspect of background is birthplace. V.P. Goryachkin's birthplace is the village Vyksa that is located in Nizhny Novgorod province. For this reason, having become a scientist, V.P. Goryachkin contributed so much to agriculture development.

The second aspect is heredity. It is known that both his father and brother were technically-gifted people. And his father was a mining factory foreman [p.5].

The third aspect is education. V.P. Goryachkin received high-quality secondary education at Moscow gymnasium. After that he studied both physics and mathematics at the Natural Science Faculty at Moscow Imperial University. Having received mechanical and mathematical education at the university, he continued his studies at the Imperial Technical School [8, p.5].

The fourth aspect is the examples to resemble. V.P. Goryachkin defended a diploma paper under the supervision of N.I. Zhukovsky who had been named as the Russian aviation forefather. He also cooperated with both S.A. Chaplygin and V.R. Williams. The former was one of the modern aeromechanics as well as aerodynamics founders. The latter was one of the modern agronomic soil science founders.

The second group comprises the factors that are farther from the person than his background. These comprise political, economic, cultural, scientific situation in the country. The most essential aspect of country's development is economic. Our country began to industrialize agricultural production after 1917. As a result, V.P. Goryachkin made a great contribution into this process [8, p.6].

The second aspect is scientific. V.P. Goryachkin emphasized that there had been no scientific paper in either Russian or any foreign language, studying farm machinery design forms and calculations [8, p.6]. It proved his research novelty.

We have also made some conclusions about V.P. Goryachkin's personality. Firstly, we suppose him to have been purposeful, because he was born into the serf man's family, that means that his parents did not have any good education. Therefore, he achieved all his success in career on his own. Secondly, V.P. Goryachkin was a self-demanding man, as having received higher education, he decided to continue his studies at the Imperial Technical School [8, p.5]. Thirdly, V.P. Goryachkin was comprehensively developed, as having received mathematical as well as technical education, he mastered as many as four foreign languages. Fourthly, V.P. Goryachkin was a creative person, because he managed to have found "the basics for building up the technical calculation theory and methods" for each farm machine [8, p.6], that is, the individual approach.

We can also understand that V.P. Goryachkin's contribution to science as well as practice has been grounded on multidisciplinary approach. The first science he has contributed to is farm engineering. Firstly, he created new science termed as agromechanics. According to its name, this science combines takes into account the interrelation existing between agriculture and engineering. The purpose of this new science is to mechanize agricultural economy sector. Secondly, V.P. Goryachkin invented some new devices. The first example we would like to give in our research is traction dynamometer, its aim being to measure the traction force in various mechanisms. The second example that is of interest for us is micro-monometer, its goal being to measure the differences in both gas and liquid pressure.

The second science which V.P. Goryachkin's research is based on is mathematics. He has created some essential machine resistance calculation formulas. Their purpose is to create a rational formular for traction resistance determination.

The third science is ed8ucation theory. V.P. Goryachkin created both scientific and methodological for higher agroengineering education.

The fourth science is education management. Firstly, he initiated to have found the Agriculture Mechanization and Electrification Moscow Institute. After that the institute was renamed into V.P. Goryachkin Moscow State Agro-engineering University. And finally, this institution was joined with V.P. Goryachkin Mechanics and Power-engineering Institute.

The research experimental part. We conducted our research practical part on the basis of DM № 12-25 first-year student group studying at V.P. Goryachkin Mechanics and Power Engineering Institute in 2025-2026 academic year. 15 students participated in our survey dedicated to V.P. Goryachkin.

We have grouped the questions as the ones about: **1. facts:** 1) Do you know Goryachkin? (20 %); 2) Do you know whether he has been an agro-engineer? (27%); 3) Do you know the term "Agromechanics"? (13%); 4) Do you know that he has created this science? (10%); 5) Do you know a number of his inventions? (7%); 6) Do you know his plow resistance formula? (5%); 7) Do you know which university has been named after Goryachkin? (53%); 8) Do you know his life years (1879–1963)? (8%); 9) Do you know where he has worked? (15%); 10) Do you know what contribution he

has made to mechanization? (25%); **2. Your own activity** - 1) Have you ever read his scientific papers? (5%); 2) Have you ever visited V. P. Goryachkin Agricultural Mechanics Museum? (10%); 3. Motivation – 1) Would you like to become as important in science as he has been? (47%); 2) Do you think his contribution is important? (85%).

The survey outcomes demonstrated that the students of the testing group have got less knowledge about V.P. Goryachkin than the insensitive to study about him.

The conclusion. Our research is of great theoretical importance, because it summarizes the knowledge about V.P. Goryachkin, enabling to evaluate his contribution to both science and practice. His work helps farmers work easier, enable the state to get more food and students to learn engineering.

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BURNS: CLASSIFICATION, MANAGEMENT AND FISH SKIN THERAPY

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Abstract. This article focuses on various types of burns, their mechanisms of development, severity levels, and methods of first aid. It describes four primary types of burns – thermal, chemical, electrical, and radiation – and examines the specific characteristics of each type regarding the depth of tissue damage, symptoms, and consequences. Additionally, the article outlines the standard classification of burns according to severity, ranging from first to fourth degree, highlighting distinct symptoms and corresponding treatments for each stage. Emphasis is placed on the importance of proper first aid administration, including neutralizing the damaging agent, treating the burn site, administering analgesics, and implementing antiseptic measures. Alternative burn treatment methods, such as utilizing fish skin, are briefly discussed, although it is noted that this approach has yet to gain widespread adoption in Russia. A comparative analysis of the chemical compositions of skins from different fish species, like salmon and catfish, was conducted, leading to conclusions about the most suitable skin for future research.

Keywords: burn classification, types of damage, first aid, fish collagen, antiseptics, alternative methods

ОЖОГИ: КЛАССИФИКАЦИЯ, ЛЕЧЕНИЕ И ТЕРАПИЯ С ИСПОЛЬЗОВАНИЕМ РЫБЬЕЙ КОЖИ

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Аннотация. В данной статье рассматриваются различные виды ожогов, механизмы их развития, степени тяжести и методы оказания первой помощи. Описываются четыре основных типа ожогов – термические, химические, электрические и радиационные – и анализируются специфические характеристики каждого типа, касающиеся глубины повреждения тканей, симптомов и последствий. Кроме того, в статье изложена стандартная классификация ожогов по степени тяжести, от первой до четвертой степени, с указанием различных симптомов и соответствующих методов лечения на каждой стадии. Особое внимание уделяется важности оказания первой помощи, включая нейтрализацию повреждающего вещества, обработку места ожога, применение анальгетиков и антисептических мер. Кратко обсуждаются альтернативные методы лечения ожогов, такие как использование рыбьей кожи, хотя отмечается, что этот подход еще не получил широкого распространения в России. Проведен сравнительный анализ химического состава кожи различных видов рыб, таких как лосось и сом, что позволило сделать выводы о наиболее подходящей коже для будущих исследований.

Ключевые слова: классификация ожогов, виды повреждений, первая помощь, рыбий коллаген, антисептики, альтернативные методы

Introduction

Burn injuries represent one of the most prevalent and debilitating forms of trauma globally, affecting millions annually. Current treatments range from topical ointments to surgical interventions, yet many lack efficiencies, particularly concerning rapid healing and minimal scarring. This study introduces an innovative solution – harnessing fish skin, specifically tilapia, as a biological dressing for burn wounds. By leveraging the unique properties of fish skin, enriched with marine collagen and possessing inherent antimicrobial qualities, this research aims to revolutionize burn care protocols. Through rigorous literature reviews, comparative analyses, and experimental trials, the study seeks to validate the feasibility and efficacy of this novel approach, offering substantial implications for global healthcare systems.

The aim of this article is to examine the types of burns, their classification, symptoms, and methods of first aid.

To achieve this goal, the following tasks need to be completed:

1. Classification of burns: different types of burns and the degree of tissue damage are discussed in detail.
2. Description of development mechanisms: the mechanisms of occurrence for each degree of burn are presented.
3. Symptoms and manifestations: the characteristic signs of different degrees of burns are described.
4. First aid: a general action algorithm is suggested to alleviate the condition of the victims and prevent complications.
5. Prohibitions and recommendations: important points regarding unacceptable actions when treating wounds are emphasized.

Results

Many foreign scientists study this topic, for example Gianluca Marcaccini, Izabela Gutovska, Mohamed Marzouk El Araby etc. [2, 3]

A burn is a complex type of injury that can occur as a result of temperature, chemical, electrical or radiation exposure to the skin. As a result of the harmful

influence of the traumatic factor, not only the skin can suffer, but also the underlying tissues. In the world classification of injuries, burns are among the most common. They can occur both in the home and in the workplace. Severe burns rank second in the number of fatalities, second only to road accidents. There are several types of burns, each of which is determined by the cause of tissue damage. The type of negative factor determines not only the prospects for recovery, but also the direction of action to help. Let's look at the 4 main types of burns and their features in more detail.

Thermal burn involves the harmful effects of high temperatures. The degree of injury is determined by factors such as: duration and temperature regime of exposure; the initial condition of the skin and the level of health of the victim. To date, it is customary to distinguish several main ways of obtaining a thermal burn:

– direct contact with fire-in the vast majority of cases provokes burns to the face and respiratory tract. There may be damage to other parts of the body, which is often complicated by infections caused by burnt clothing.

– boiling water-burns of this type differ in depth, even with a small area of damage.

– steam-creates a shallow injury to the upper layers of the skin and often affects the mucous membranes of the upper respiratory tract.

– hot objects – even a short contact can leave clear traces that are nothing more than deep injuries.

Chemical burns occur when caustic substances of various types get on the surface of the skin. The degree of injury is determined by the concentration of components such as:

– acid-causes shallow lesions. After short-term exposure, it provokes the formation of a crust, which prevents further penetration of chemicals;

– alkali – provokes a deep lesion;

– heavy metal salts-cause surface damage.

– the most severe and difficult to treat chemical burns occur when injured with alkaline agents.

Electric burns occur immediately after contact with the current itself or any materials that can conduct the discharge through themselves. At the time of injury, an electric current pass through the muscles and blood, as well as through the skin and bones. A life-threatening electric shock is above 0.1 amps. The area of damage is characterized by a relatively small size, but at the same time the maximum depth of the lesion. When a lesion occurs, two points are formed on the body: the entrance and exit of the discharge.

The most common variant of radiation burn is ultraviolet radiation damage, which gives a large surface area of damage, for example, after prolonged sunburn in the sun. Ionizing radiation has a negative effect not only on the condition of the skin, but also on other tissues, as well as on the work of internal organs. Infrared radiation most often causes deterioration of visual acuity, due to the aggravation of the retina and cornea [5].

According to the generally accepted classification from 1960, it is customary to distinguish I, II, III-A and III-B, as well as IV degrees of burns. Each of them has a certain mechanism of development, symptoms and suggests characteristic features of manifestations. Let's look at all this in more detail.

I degree. Mechanism of development: damage to the surface layers of the skin. Healing for 3-4 days, does not involve the formation of a scar.

Manifestations: the appearance of redness, local swelling and soreness. The area of affected skin is sensitive when touched. There may be a violation of the functionality of the affected area.

II degree. Mechanism of development: the surface layers of the skin are completely damaged. Healing for 10-12 days, without scar formation.

Symptoms: redness, swelling and soreness of the affected area, the appearance of blisters filled with a clear liquid.

III-A degree. Mechanism of development: not only the upper layers of the skin are damaged, but also the dermis is partially affected, but the hair follicles, as well as the sebaceous and sweat glands remain intact. Within 4-6 weeks, a dry or soft burn crust of a light brown hue forms.

Manifestations: there is tissue death, as well as extensive swelling of the skin in the damaged area. Sensitivity is preserved, but greatly reduced. Blisters with a diameter of 2 cm or more are formed, filled with a yellow thick liquid.

III-B degree. Mechanism of development: all the surface layers of the skin are damaged, the dermis suffers, and the hypodermis is also partially affected. Self-healing of wounds is impossible, complex treatment is required.

Manifestations: there is a death of tissues throughout the thickness of the epidermis, partially affected subcutaneous fat. Under the influence of negative factors, bubbles form with a liquid in which blood streaks are observed. Formation of a dense, dry burn crust of a dark brown hue.

IV degree. Mechanism of development: the skin, muscles and tendons are damaged, and the bone structure may be affected. There is intoxication and risks of serious complications.

Manifestations: charring of tissues, formation of a dark burn crust, through which the venous network is visible. There is no pain due to the destruction of nerve endings.

In order to alleviate the condition of the victim and at the same time not aggravate the situation, it is important to consider the type of burn when providing first aid. This is the only way to neutralize the harmful effects as effectively as possible. A universal algorithm for providing care for various types of burns:

1. Identification and elimination of the aggressive factor.
2. Appropriate treatment of the burn site.
3. Pain relief with non-prescription medications
4. Carrying out a complex of antiseptic measures.

5. Normalization of the victim's condition and, if necessary, seeking emergency medical care.

It is forbidden to open the formed blisters. To avoid bleeding, without the participation of specialists, it is not allowed to tear off fragments of damaged items. Do not treat burns with vodka, alcohol, green or iodine. Do not use pure ice to cool the wound. Forget about alternative medicine for thermal burns [1].

This method of treatment will be most effective for radiation and thermal burns, since the shallow layers of the skin are affected (chemical is treated individually depending on the substance that caused the burn), except for the 4th degree of thermal damage – in this case, only amputation or complete removal of the damaged area will help (since dead cells tissues cannot be restored).

In the Russian Federation, method of analog of the skin treatment is not popular, or rather, it is not used at all. Fish waste is not used anywhere, so tilapia skin is not available on open sources. from this – of collagen due to which tissue regeneration occurs in patients. Thanks to the glands located in the outer layer (epidermis), the skin is covered with a special mucus that has antimicrobial and antiseptic properties, thanks to which the fish body is protected from harmful microorganisms. The dirtier the abode, the more slime there is. Tilapia is considered a garbage, sewer fish, so its body is abundantly covered with mucus. Some have scales. The deeper layer (dermis) contains blood vessels, nerves, and pigment cells – some of which contain metals. To shorten the search list, we exclude the fish with the highest mercury content and use only the fish with the lowest value for analysis: salmon, catfish, cod, pollock, and tilapia. We do not take tilapia, as its skin is not available in the Russian Federation (it is simply thrown away). Next, we will analyze (compare) the chemical composition of tilapia and these fish with the substances contained in the fish skin: vitamin E, fluorine, chromium, selenium, protein.

Catfish and salmon are most similar in chemical composition, so we take them as an analog for further experiments. Salmon is an active fishing industry, so it is not difficult to purchase it. The skin of salmon is covered with scales, very strong, thick, elastic, but has metals in the composition, which will not have a very good effect on the patient: it will manifest itself in the form of allergic reactions, slow recovery, regeneration. Relative to the cost - not cheap. Catfish has a good skin composition (≈65% similarity to tilapia skin) and lives in different parts of the world: in the north and south. Unfortunately, due to poaching and uncontrolled catch, the number of catfish in water bodies has decreased, so in terms of economy, it is not profitable to take this fish to reproduce a new industry. We can conclude that salmon skin is most suitable.

Butchering salmon is very difficult: the muscle tissue is tightly connected to the dermis, a rotten smell, in the form of a gaseous substance – trimethylamine, is clogged into the nostrils, causing gag reflexes, which complicates the process of butchering. Bones and cartilage are the most difficult to separate from the skin.

Scientists developing a method for treating tilapia skin burns treated the tissue with special antiseptic agents, ridding it of harmful microorganisms and a rotten smell (trimethylamine). Fish skin contains collagen – the main regenerating property. So, you need to treat the tissue so that the collagen and protein do not denature (denaturation of collagen is the destruction (branching) of stronger amino acids and its transformation into gelatin under the influence of high temperatures). There are different classifications of antiseptics, from which we will exclude those that negatively affect the burn: alcohols, iodine, acids and brilliant green [4].

Conclusion

This investigation underscores the transformative potential of incorporating fish skin into modern burn wound management strategies. The findings highlight the synergistic advantages of tilapia skin's collagen-rich composition, its compatibility with human physiology, and its capacity to accelerate wound healing processes.

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УДК 81-26

THE IMPACT OF ELECTROLYTE IMBALANCE OF POTASSIUM ON HOMEOSTASIS ON DOGS AND CATS

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Abstract: Maintenance of electrolyte homeostasis plays a crucial role in the normal functioning of the animal organism. Potassium, as the primary intracellular electrolyte, is involved in maintaining neuromuscular conduction, proper cardiac activity, and acid–base balance, which are essential for overall physiological stability. This review examines the physiological role of potassium, the mechanisms regulating its metabolism, and the consequences of hypokalemia and hyperkalemia for homeostatic processes in companion animals—dogs and cats. Based on the analysis of scientific publications on disorders of potassium regulation in veterinary medicine, it is shown that deviations in plasma potassium levels can lead to significant dysfunctions of the nervous, skeletal, and cardiovascular systems.

Keywords: electrolyte disorders in dogs and cats, potassium, homeostasis, hyperkalemia, hypokalemia, dogs, cats

ВЛИЯНИЕ НАРУШЕНИЙ ЭЛЕКТРОЛИТНОГО БАЛАНСА КАЛИЯ НА ГОМЕОСТАЗ У СОБАК И КОШЕК

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Аннотация: Поддержание электролитического гомеостаза имеет ключевое значение для стабильной работы организма животных, обеспечивая нормальное функционирование всех физиологических систем. Калий, являясь главным внутренним электролитом клетки, участвует в обеспечении физиологически нормальной нейромышечной проводимости, работе сердца и поддержании кислотно-основного равновесия, что крайне важно для общего

физиологического равновесия. В представленном обзоре анализируются физиологическая роль калия, пути контроля его обмена, а также последствия развития гипокалиемии и гиперкалиемии для процессов гомеостаза у домашних питомцев – собак и кошек. На основе анализа научных публикаций, посвящённых расстройствам калиевой регуляции в ветеринарии, демонстрируется, что любые отклонения уровня калия в плазме способны вызывать значительные дисфункции нервной, скелетной и сердечно-сосудистой систем, что существенно влияет на состояние животных.

Ключевые слова: электролитные нарушения у собак и кошек, калий, гомеостаз, гиперкалиемия, гипокалиемия, собаки, кошки

Introduction

The stability of the internal environment of the body is a necessary condition for the normal functioning of all physiological systems. Electrolyte balance plays a significant role in ensuring homeostasis, as it determines the concentration of major ions in body fluids. Among these, potassium is of particular importance as the main intracellular cation, with approximately 98% of it localized within cells. Potassium is involved in regulating osmotic pressure and acid–base balance, ensures the conduction of nerve impulses and muscle contraction processes, and is also associated with protein metabolism. Disorders of potassium balance are relatively common in dogs and cats and may accompany various pathological conditions, including kidney diseases, endocrine disorders, and gastrointestinal pathologies. Changes in potassium concentration in the blood can lead to disturbances in neuromuscular transmission, cardiac rhythm abnormalities, and other functional disorders, which significantly affect the condition of the animal organism.

Therefore, studying the role of potassium in maintaining homeostasis and the consequences of its imbalance is of great importance for veterinary medicine. The aim of this article is to analyze the influence of potassium metabolism disorders on homeostasis in dogs and cats.

Aim of the study

To study the relationship between electrolyte metabolism disorders and system dysfunctions in the body to improve understanding of diagnostic and therapeutic approaches for dogs and cats.

Objectives

1. To analyze scientific literature describing the mechanisms of electrolyte balance regulation in healthy cats and dogs.
2. To document the main types of diseases associated with potassium imbalance that are characteristic of dogs and cats.
3. To summarize data on the diagnostic significance of laboratory parameters for assessing the severity of the patient’s condition.

Material and methods

A review and analysis of domestic and foreign sources were conducted. A literature search was performed in electronic databases (eLibrary, SciHub, Google Scholar) and print publications (textbooks on animal physiology). The analysis included 8 scientific sources. The data were also supported by clinical observations

(clinical cases from personal work experience in a veterinary clinic). The methodological basis of the work was a comparative analysis of literature data and practical observations.

Physiological Role of Potassium in the Body of Dogs and Cats

Potassium is one of the main electrolytes in the body and plays an important role in ensuring the normal functioning of cells and tissues in dogs and cats. It participates in the formation and maintenance of the potential difference across cell membranes, which is essential for the generation of nerve and muscle action potentials. As a result, potassium ensures the transmission of nerve impulses and the proper functioning of the nervous system. This mineral also plays a significant role in the functioning of the muscular system [8]. The processes of muscle contraction and relaxation, including those of the cardiac muscle, largely depend on potassium metabolism in the body. Potassium contributes to maintaining the automaticity of cardiac activity and a normal heart rhythm, whereas its deficiency may lead to the development of arrhythmias and other cardiac disorders. This electrolyte is also involved in various metabolic processes. It acts as a cofactor for several enzymes and participates in the synthesis of DNA, proteins, and glycogen. In addition, potassium is an important component of sodium–potassium exchange, which ensures cellular metabolism, maintains water–electrolyte balance, and regulates the proper distribution of fluids in the body. Moreover, potassium influences bone tissue by helping to reduce bone resorption processes. A deficiency of this element may lead to impaired muscle function, as well as the development of cramps and muscle spasms.

Regulation of Potassium Homeostasis

The kidneys are the principal organs responsible for regulating potassium homeostasis, with potassium being predominantly excreted via urine; any impairment of renal function can result in alterations in serum potassium levels. Hormonal mechanisms play a central role in this regulation: aldosterone enhances renal potassium excretion, whereas insulin promotes the cellular uptake of potassium from the extracellular compartment. Additionally, potassium distribution is influenced by variations in acid-base status, hydration levels, and cardiovascular function. Body water balance is closely linked to the cations sodium and potassium, with sodium serving as the main cation of the extracellular fluid and potassium predominantly confined to the intracellular space. Humoral mechanisms regulating water and electrolyte balance control the extent of water and sodium loss and are mediated by three key hormones: antidiuretic hormone (ADH) from the pituitary, vasopressin, and the adrenal hormone aldosterone. These hormones exert their effects primarily on the kidneys, which constitute the most critical organ for maintaining homeostasis of water and electrolytes.

Disorders of Potassium balance in dogs and cats

Potassium homeostasis is critical for cellular and organ function, with both hypo- and hyperkalemia posing significant clinical risks. **Hypokalemia**, defined as serum potassium below 3.5 mEq/L, may be caused by gastrointestinal losses, renal disease,

diuretic therapy, or inadequate dietary intake. Mild cases are often asymptomatic, while more severe depletion affects nerves and muscles, leading to weakness, impaired coordination, cardiac arrhythmias, and, in cats, hypokalemic myopathy characterized by profound muscle weakness and inability to maintain head posture. Severe cases may progress to rhabdomyolysis, ascending paralysis, and respiratory compromise, with symptom severity influenced by pre-existing cardiac disease and the rate of potassium decline.

Hyperkalemia, defined as serum potassium above 5.0 mmol/L, is the most common electrolyte disorder associated with life-threatening arrhythmias and cardiopulmonary arrest. It can be classified as mild (5.0–5.9 mmol/L), moderate (6.0–6.4 mmol/L), or severe (≥6.5 mmol/L), with concentrations above 10.0 mmol/L typically fatal without urgent intervention. Clinical signs, which are generally nonspecific and occur primarily in severe cases, include weakness, flaccid paralysis, paresthesia, depressed deep tendon reflexes, and respiratory difficulty. Diagnosis and management rely on serum biochemical analysis and electrocardiography to guide appropriate therapy.

Diagnosis and Clinical Significance

The diagnosis of potassium metabolism disorders is based on laboratory analysis of blood and urine. Determination of potassium concentration is an important component of biochemical blood testing in animals. Additionally, electrocardiographic examinations may be used to detect changes in heart rhythm associated with electrolyte imbalance. Timely diagnosis and correction of potassium levels are of great importance for preventing severe complications and maintaining normal homeostasis in animals.

Conclusion

Potassium electrolyte balance plays a key role in maintaining the normal functioning of vital body systems in dogs and cats. Disorders of potassium metabolism, including hypokalemia and hyperkalemia, can cause serious pathological changes, primarily affecting the cardiovascular and neuromuscular systems, and may pose a direct threat to the life of animals. In this regard, the timely diagnosis of potassium metabolism disorders, based on laboratory and clinical research methods, as well as the timely correction of potassium levels, are important tasks of modern veterinary medicine. Monitoring electrolyte balance significantly reduces the risk of severe complications and increases the effectiveness of treatment, ensuring the maintenance of physiological homeostasis in animals.

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FOOD SECURITY OF NEW REGIONS OF THE RUSSIAN FEDERATION: CHALLENGES AND MEASURES OF STATE SUPPORT

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Abstract: The article analyzes the challenges of food security in four new subjects of the Russian Federation (Donetsk and Lugansk People's Republics, Zaporizhia and Kherson regions) in the context of a special military operation in the period 2022-2025. Key destabilizing factors have been identified. Special attention is paid to the three-tier system of state support, including emergency non-monetary interventions, large-scale humanitarian demining and preferential financial mechanisms. A model for consolidating the accumulated experience is proposed.

Keywords: food security, post-conflict agricultural recovery, government support for agriculture

ПРОДОВОЛЬСТВЕННАЯ БЕЗОПАСНОСТЬ НОВЫХ СУБЪЕКТОВ РОССИЙСКОЙ ФЕДЕРАЦИИ: ВЫЗОВЫ И МЕРЫ ГОСУДАРСТВЕННОЙ ПОДДЕРЖКИ

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Аннотация: В статье анализируются вызовы продовольственной безопасности четырёх новых субъектов Российской Федерации (Донецкая и Луганская народные республики, Запорожская и Херсонская области) в условиях специальной военной операции в период 2022–2025 гг. Выявлены ключевые дестабилизирующие факторы. Особое внимание уделено трехуровневой системе государственной поддержки, включающей экстренные неденежные интервенции, масштабное гуманитарное разминирование и преференциальные финансовые механизмы. Предложена модель закрепления накопленного опыта.

Ключевые слова: продовольственная безопасность, постконфликтное восстановление сельского хозяйства, государственная поддержка АПК

In 2022, four new regions were joined to the Russian Federation in turn – the Donetsk and Lugansk People's Republics, the Zaporizhia and Kherson regions [10]. All of them have always been famous for their fertile chernozems, but by the time they became part of the Russian Federation, agriculture there lay practically in ruins. Among the reasons – a military operation was carried out, millions of mines lay in the fields, people left, equipment was broken or stolen, there are no seeds, no fertilizers either. [7]

The state immediately began to solve the problems, because it was necessary to feed the people at the same time that the fighting was going on. In a little over three years, it was possible to bring the agricultural sector of these territories almost to the pre-war level [6] – and in such a situation it looks like a feat. It turned out to be a unique experience, and it can be used in other "hot spots" if necessary.

The purpose of this article is to analyze this experience, in particular, government support measures. The research material is the official statistics of the Ministry of Agriculture and some regulations [4, 8]. The research method is a comparative analysis of the dynamics of the main indicators.

Such issues have been a subject of scientific interest and research by different scientists, including interdisciplinary inquiries [1, 9].

The authorities actively responded to the crisis in the new regions. New support methods were being introduced that had not previously been used to such an extent and with such speed. To help the new regions, a three-tier support system was created, in which each level performed its own function and formed the basis for the next one.

The first level is emergency non-monetary interventions (2022 - the first half of 2023). As a result of the reform of the agricultural supply system, the state has become the main supplier of funds and tools for agricultural enterprises. 122 thousand tons of grain and oilseeds were delivered to the new regions, including 78% of the total volume. elite and first reproductions); 185 thousand tons of mineral fertilizers; there are more than 3.1 thousand units of agricultural machinery and over 12 thousand units of attachments in the warehouse. and trailed equipment; over 1.2 million liters of most plant protection products were supplied on a gratuitous or conditionally reimbursable basis with a deferred payment of up to 5 years at 0.1% per annum [6].

Starting in 2023, a systematic recovery began using an integrated approach and special regulations that accelerated the allocation of funds without lengthy tenders.

The second level is the simultaneous mine clearance and restoration of the path to the ground. The farmland demining program conducted by the Russian Ministry of Emergency Situations and the engineering troops of the Ministry of Defense helped to return 1.18 million hectares of land to circulation by December 2025 [5]. The main focus was on the clearance of agricultural land, which allowed an additional 2 million hectares to be used for their intended purpose in 2024.

Since 2023, the new regions have been fully included in all federal programs, but on super favorable terms: loans at 5%; compensation of up to 70% of the cost of Russian equipment (instead of the usual 30-50%); in 2023-2024, fuel and lubricants for spring work were fully compensated.

The third level is financial and other instruments used from 2023 to the present. Since 2023, new regions have been fully included in government programs with preferential terms [11]. Since 2024, a free economic zone with zero income tax for 10 years has been created; special crop insurance has been introduced, which covers the risks of military operations and mines.

The Ministry of Emergency Situations and military engineers were working at their limits. By December 2025, 1.18 million hectares had already been cleared, and more than 3 million hectares had been returned to circulation. Without this step, all other investments would simply have burned out – the money is there, the seeds are there, but you can't go out into the field because there are mines [3]. Below, in Figure 1, the figures [2] are presented, showing how difficult the situation was and how everything has changed:

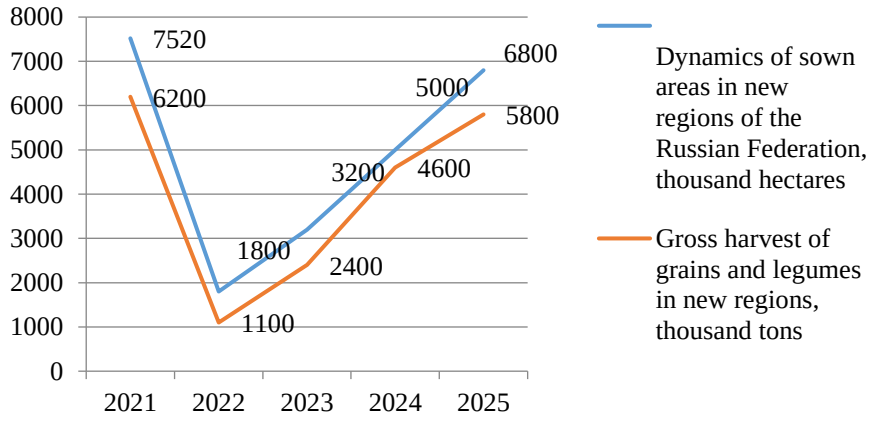

Figure 1. Dynamics of cultivated area

Thus, the results of grain harvesting have increased fivefold in three years. Self-sufficiency in grain is now more than 180%, and milk is almost 95%. The regions have started selling grain to other parts of Russia again, rather than just providing for themselves.

This happened because we did everything at the same time and in three directions, without waiting for the previous stage to end.

The dynamics of financial support is shown in Figure 2.

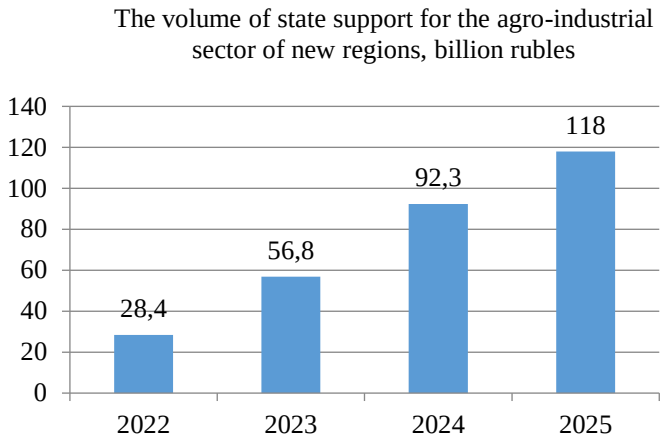

Figure 2. The amount of government support.

In just four years, almost 300 billion rubles of state support have been contributed, three quarters of them to machinery, seeds, fertilizers, and restoration of production.

Private investors have also joined in: by the end of 2025, they have invested 87 billion in recycling and storage because it has become profitable and it is clear that the land has been cleared and it is possible to work.

What is the current difficulty:

– There are still few processing plants
– There is a catastrophic shortage of personnel (many left and did not return)
– There are still mines in some areas

We can suggest the following ways to solve problems:

1. Create a separate federal fund specifically for the new territories, which will operate until 2030. That is, not just to “include them in common programs,” but to allocate separate money.
2. Launch a special grant from Agrostartap New Regions – up to 10 million rubles per household with almost no conditions.
3. Provide zero leasing for Russian equipment for 7 years. That is, to take a tractor, combine harvester, seeder, etc. without interest at all, to pay only the body of the loan and for a long time.
4. Continue mine clearance to zero, because as long as at least one site is mined, investors will not go there, nor will local residents
5. Build processing plants (dairies, elevators, oil mills, flour mills, etc.). Now they grow a lot of grain, but it is not profitable to sell it – they carry raw materials, losing money. It is much more profitable to recycle everything on the spot.
6. Solve the issue of personnel – there are still not enough people, especially machine operators, agronomists, veterinarians. We need separate retraining and relocation programs for specialists in these areas with lifting and housing.

Conclusion: even in the conditions of ongoing hostilities, it is realistic to almost completely restore the agricultural sector of the region with good natural potential in

three years. It is important to do everything at the same time: to clear mines, bring in material resources and give benefits.

The study showed that even during active hostilities, the food base of a region with good agricultural potential can be almost completely restored in three years. The experience gained in operational mine clearance and targeted logistical assistance in 2022-2025 plays an important role in this process. Over-the-top financing has a high degree of importance.

The experience gained in 2022-2025 in restoring agriculture in new regions of the Russian Federation has the potential to be successfully applied in other territories affected by armed conflicts, both inside and outside the country. An integrated approach combining rapid mine clearance, targeted logistical assistance and extra-extensive financing makes it possible to return fertile lands to circulation in a relatively short time – three to four years – and ensure sustainable food security even in the face of ongoing hostilities.

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УДК 81-26

DIAGNOSIS OF RABIES IN DOGS DURING A VETERINARY APPOINTMENT

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Abstract: The results of the literature analysis on the topic under study are presented. The analysis of the three main stages of rabies in dogs (prodromal, excitation, and paralysis) is carried out, and the main signs that can be clinically diagnosed at these stages are identified. In the prodromal stage, there are changes in behavior and increased breathing, in the excitation stage, there is aggression and salivation, and in the paralysis stage, there is tremor and paralysis. An algorithm has been formulated that will allow for the detection of signs of rabies in a dog during a veterinary visit as quickly as possible, which will increase the safety of veterinary doctors and pet owners. A flowchart is provided for a veterinarian to follow in the event of a dog bite with unknown rabies status or confirmed rabies.

Keywords: rabies, clinical diagnostics, dogs, symptoms of rabies

ДИАГНОСТИКА БЕШЕНСТВА У СОБАК ВО ВРЕМЯ ВЕТЕРИНАРНОГО ПРИЁМА

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Аннотация; Представлены результаты анализа литературы по исследуемой теме. Проведен анализ трех основных стадий бешенства у собак (продромальной, стадии возбуждения и паралитической стадии), выявлены основные признаки, которые могут быть клинически диагностированы на данных стадиях. На продромальной – изменения в поведении учащённое дыхание, на стадии возбуждения – агрессия и слюнотечение, а на паралитической стадии – тремор и параличи. Сформулирован алгоритм, который позволит выявить признаки бешенства

у собаки во время ветеринарного приёма как можно быстрее, что повысит безопасность ветеринарных врачей и владельцев питомца. Представлена схема действий для ветеринарного врача в случае укуса собаки с неизвестным статусом бешенства или с подтверждённым бешенством.

Ключевые слова: бешенство, клиническая диагностика, собаки, симптомы бешенства, ветеринария

Rabies is one of the most ancient and dangerous viral diseases common to humans and animals. Despite the achievements of modern medicine, it remains almost 100% fatal after the first clinical signs appear. This is an RNA-containing virus. Its genetic material is protected by a dense shell, which, however, is extremely sensitive to the external environment: the virus quickly dies when heated, exposed to direct sunlight or conventional disinfectants. The main feature of the rabies virus is its neurotropicity. This means that it affects only the nervous system. Infection occurs through saliva when a person is bitten or when the virus enters damaged skin. Once the virus enters the muscle, it does not immediately enter the bloodstream (where it would be quickly destroyed by the immune system). Instead, it finds its way to the peripheral nerve endings and begins a slow journey towards the spinal cord and brain. Once the virus reaches the brain, it causes severe encephalitis. It affects the centers responsible for breathing, swallowing, salivation, and be Rabies is one of the most ancient and dangerous viral diseases common to humans and animals, with historical records of the disease dating back to antiquity. Despite the significant achievements of modern medicine and advances in virology, it remains almost 100 % fatal after the first clinical signs appear, which underscores the critical importance of preventive measures and timely intervention. This disease is caused by the rabies virus (Lyssavirus genus, Rhabdoviridae family), which is an RNA-containing virus. Its genetic material is protected by a dense protein shell, or capsid, surrounded by a lipid envelope. This structure, however, is extremely sensitive to the external environment: the virus quickly loses its viability when exposed to high temperatures direct sunlight, ultraviolet radiation, or conventional disinfectants such as ethanol, iodine solutions, and bleach. Nevertheless, in low temperatures or in organic matter (e.g., saliva), the virus can persist for a certain period, maintaining its infectious potential. The main feature of the rabies virus is its pronounced neurotropicity – the ability to specifically target and infect nervous tissue. This means that it affects only the nervous system, spreading along nerve pathways rather than via the bloodstream or lymphatic system. Infection most commonly occurs through the saliva of an infected animal, typically via a bite wound. It can also occur if the virus-laden saliva comes into contact with abraded skin, mucous membranes, or open wounds, although this is less frequent.

Once the virus enters the muscle tissue at the site of inoculation, it does not immediately enter the bloodstream (where it would be quickly detected and potentially neutralized by the immune system). Instead, it binds to acetylcholine receptors at the neuromuscular junction and gains access to the peripheral nerve endings. From there, it begins a slow retrograde axonal transport – a journey along the nerve fibers – towards

the spinal cord and, ultimately, the brain. The speed of this progression is relatively slow (approximately 3–25 mm per day), which explains the typically prolonged incubation period that can range from several weeks to several months, or even longer in rare cases.

Once the virus reaches the central nervous system (CNS), it causes severe, rapidly progressing encephalitis. It preferentially affects key brain centers responsible for vital functions, including breathing, swallowing, salivation, thermoregulation, and behavioral control. As the infection spreads within the CNS, neurons undergo severe pathological changes and, ultimately, disintegrate. This widespread neuronal damage leads to a cascade of neurological deficits and autonomic dysfunction. Clinical manifestations include hydrophobia (fear of water due to painful spasms when attempting to drink), aerophobia, hyperactivity, hallucinations, and periods of aggression followed by paralysis. Once these symptoms appear, the disease progresses rapidly, and death usually occurs within a few days due to respiratory failure or cardiac arrest. Consequently, the neurons' literal disintegration leads to the inevitable death of the organism.

In dogs, the course of a disease such as rabies is characterized by the presence of stages. Each stage has its own name and specific symptoms. The first stage is the Prodromal stage (lasting 1-3 days): a sudden change in behavior (fear or excessive affection), photophobia, and excessive licking of the bite site. Additionally, the dog's body temperature rises. Normally, a dog's body temperature is up to 39 degrees Celsius, but in cases of rabies, it can reach 40-41 degrees Celsius. The second stage is the Excitation stage (3-4 days): Aggression without cause, excessive salivation, violation of the breathing rhythm, tremors and hydrophobia. The last stage is the Paralitic stage (1–5 days): excessive salivation, sagging of the lower jaw, paralysis of the hind limbs.

Below is a step-by-step algorithm for quickly assessing a dog's rabies status during an appointment.

Step 1. Preliminary anamnesis collection (remote). Before making physical contact with the animal or removing it from the carrier/muzzle:

1. Vaccination status: it is necessary to check the animal's veterinary passport or ask the owner whether there is a valid rabies vaccination. (Absence is a risk factor.)
2. Contact history: determine whether there have been any contacts with wild animals (foxes, raccoons, bats) or stray dogs over the past 2–6 months.
3. Behavioural changes: ask the owner whether they have noticed a sudden change in the animal's temperament.

Step 2. Visual examination at a distance (safe distance). It is necessary to assess the animal's general appearance and motor function without making direct contact:

1. Eyes and muzzle: dilated pupils (mydriasis) that do not react to light, or anisocoria (unequal pupil size) may indicate that the dog has rabies.
2. Drooping lower jaw: if the dog has the final stage of rabies, due to paralysis of the masticatory muscles, the dog is unable to close its mouth.

3. Salivation: profuse secretion of viscous saliva, often foamy, is highly indicative of rabies. This occurs due to the inability to swallow liquid (pharyngeal paralysis).

Step 3. Assessment of neurological responses and reflexes conducted with safety precautions in place (the animal must be restrained):

1. Hypersensitivity: reaction to light (photophobia): sudden restlessness or aggression when bright light is switched on. Reaction to sound: convulsions or aggression in response to a sudden clap or noise. This is an extremely alarming symptom; if present, the animal most likely has rabies.

2. Coordination: unsteady gait, falling to one side, and paralysis are characteristic of rabies.

If any of these symptoms are detected during a dog's examination, the veterinarian should immediately stop the appointment and contact the animal rabies control service.

If a dog bite has occurred during a veterinary appointment, the rabies status of which is not known, or a dog with confirmed rabies, the doctor should consider the situation as potentially dangerous and follow the following action plan.

1) First you need to treat the bite site (in the first 15 minutes).

It is important to remember that the rabies virus is extremely sensitive to an alkaline environment. It is necessary to wash the saliva from the wound as much as possible and destroy the virus shell.

To do this, wash the wound with running water and household soap for 10-15 minutes. Don't be afraid to rub the wound with a sponge or cloth.

After washing, treat the wound edges with 70% alcohol or 5% iodine solution. Fortunately, they can be found in any veterinary clinic.

2) Next, it is necessary to isolate the animal that committed the bite. According to veterinary legislation, a dog that bites a human should be isolated for observation for 10-14 days. Ideally, it is better to place the dog in the infectious diseases hospital of the clinic (if there are conditions) or immediately inform the State Veterinary Service, where the owners are required to deliver the animal for examination. If the dog is alive and well after 10 days, it means that there was no virus in its saliva at the time of the bite, and the course of vaccinations for the doctor can be shortened.

3) Then, you need to get to the nearest emergency room, where you will be referred to a hospital where you will receive a rabies vaccine. Even if you have been vaccinated before (for prevention purposes, for example), you still need to medical help after a bite. The incubation period of rabies in humans ranges from 10 days to 3-4 months, in some cases up to one year, but you should get help in the next 72, preferably 24 hours, to reduce the risk of the disease.

4) Legal registration is a necessary step if an animal that is potentially infected with rabies bites a patient at a veterinary clinic.

The doctor is required to submit a report about the animal that bit the patient to the state veterinary service in their area. In addition, the name, address, and phone number of the dog's owner should be recorded.

In conclusion, it can be said that rabies is an extremely dangerous disease that does not give a second chance – it is nearly always fatal once symptoms develop. Therefore, prevention is key. It is necessary to be attentive to animals at the reception. The main rule is to avoid bites even from domestic animals. If such an incident happens, it is crucial to seek medical help in a timely manner.

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THE ROLE OF BIM TECHNOLOGIES IN REDUCING PROJECT ERRORS IN CONSTRUCTION

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Abstract: The article examines the role of Building Information Modeling (BIM) technologies in minimizing design errors within the construction industry. The study analyzes the primary categories of errors arising during traditional design processes and demonstrates how BIM-based workflows contribute to their systematic reduction. The research identifies the key functional capabilities of BIM platforms — including clash detection, parametric modeling, and interdisciplinary coordination — that directly address the root causes of project inaccuracies. The findings indicate that the implementation of BIM technologies significantly decreases the frequency of design conflicts, reduces rework costs, and shortens project delivery timelines. The article concludes that the widespread adoption of BIM represents a strategic pathway toward improving quality control and overall project performance in the construction sector.

Keywords: BIM technologies, design errors, clash detection, parametric modeling, construction project management, information modeling, interdisciplinary coordination

РОЛЬ BIM-ТЕХНОЛОГИЙ В СОКРАЩЕНИИ ОШИБОК ПРОЕКТА В СТРОИТЕЛЬСТВЕ

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Аннотация: В статье рассматривается роль технологий информационного моделирования зданий (BIM) в минимизации проектных ошибок в строительной отрасли. Анализируются основные категории ошибок, возникающих в ходе традиционного проектирования, и показывается, каким образом рабочие процессы на основе BIM способствуют их систематическому устранению. Выявлены ключевые функциональные возможности BIM-платформ — включая обнаружение коллизий, параметрическое

моделирование и межотраслевую координацию, — которые непосредственно устраняют первопричины неточностей проекта. Результаты исследования свидетельствуют о том, что внедрение BIM-технологий значительно снижает частоту проектных конфликтов, уменьшает затраты на переработку и сокращает сроки реализации проекта.

Ключевые слова: BIM-технологии, ошибки проектирования, обнаружение коллизий, параметрическое моделирование, управление строительными проектами, информационное моделирование, межотраслевая координация

Introduction

The construction industry is characterized by a high degree of complexity arising from the involvement of multiple professional disciplines, extended project timelines, and significant financial investment. Under these conditions, design errors represent one of the most consequential sources of risk, leading to cost overruns, schedule delays, and, in critical cases, structural failures. According to various industry analyses, a substantial proportion of construction project losses can be attributed to errors and omissions generated during the design phase rather than during physical construction [1].

Traditionally, design workflows relied on two-dimensional drawings and disconnected documentation systems, which made it difficult to detect contradictions between different engineering disciplines in advance. The emergence of Building Information Modeling (BIM) as a comprehensive digital methodology has fundamentally altered this landscape by enabling the creation of integrated, three-dimensional, data-rich project models accessible to all project stakeholders simultaneously [2].

The present study investigates the specific mechanisms through which BIM technologies reduce the incidence of project errors, with the aim of providing a structured understanding of the relationship between digital modeling capabilities and design quality outcomes.

Objective

The objective of this research is to analyze the role of BIM technologies in reducing design errors during the pre-construction phase of building projects, and to identify the specific functional features of BIM platforms that contribute most significantly to error reduction.

Tasks

In order to achieve the stated objective, the following research tasks were formulated:

1. To classify the primary types of project errors encountered in conventional construction design workflows.
2. To examine the functional capabilities of BIM platforms relevant to error prevention.
3. To evaluate the impact of BIM implementation on project error frequency and associated rework costs based on available research data.
4. To draw conclusions regarding the practical significance of BIM adoption for construction quality management.

Materials and Methods

The research is based on a review and synthesis of academic literature, industry reports, and case study findings published between 2018 and 2024. Sources were selected from databases including Scopus, Web of Science, and the Russian Science Citation Index (RINC/eLIBRARY). The methodological approach combines descriptive analysis with comparative evaluation of project outcomes in BIM-enabled versus traditional design environments.

Key BIM platforms examined in the course of this research include Autodesk Revit, Bentley AECOsim Building Designer, and Renga Architecture, as these represent widely adopted solutions in both international and Russian construction markets [4].

Results

Classification of project design errors. Design errors in construction projects may be grouped into three principal categories. The first category encompasses geometric conflicts, whereby structural, architectural, and mechanical-electrical-plumbing (MEP) elements physically intersect or lack the required clearance distances. The second category consists of information inconsistencies, including contradictions between plans, sections, elevations, and technical specifications. The third category involves omissions, where components required for construction or functional operation are absent from the project documentation [5].

All three categories of errors share a common root cause: the use of disconnected data sources maintained by separate design teams without a unified information environment. Errors of this nature often remain undetected until the construction phase, at which point their resolution requires costly and time-consuming rework [3].

BIM technologies and their role in error reduction. Building Information Modeling addresses the root causes of design errors through several interconnected mechanisms.

Firstly, BIM enables centralized information management. All disciplines — architecture, structural engineering, and MEP – work within a single shared model or federated model environment. This approach eliminates the information fragmentation inherent in paper-based and CAD-based workflows, ensuring that any modification made by one specialist is immediately visible to all others [2].

Secondly, automated clash detection is one of the most impactful BIM capabilities for error reduction. Dedicated tools within platforms such as Autodesk Navisworks or BIM 360 systematically scan the project model for geometric intersections and proximity violations between elements belonging to different disciplines. Studies indicate that the use of clash detection tools can identify thousands of potential conflicts prior to construction commencement, dramatically reducing the volume of field-based problem resolution [6].

Thirdly, parametric modeling ensures that changes to design parameters propagate automatically throughout all associated model elements, drawings, and schedules. This eliminates a significant source of human error — the manual updating

of multiple documents following a design revision — and maintains internal consistency across the entire documentation set.

Fourthly, BIM supports enhanced interdisciplinary coordination through regular model federation and review sessions. Structured coordination workflows, supported by BIM Coordination protocols, create formal checkpoints at which project teams examine the combined model for unresolved conflicts and documentation gaps [1].

Quantitative impact on error rates. A number of published studies report measurable reductions in design error frequency following BIM adoption. Research conducted on large-scale infrastructure projects found that the implementation of coordinated BIM workflows reduced the number of requests for information (RFIs) — a key indicator of on-site design discrepancies — by between 40% and 60% compared with equivalent projects executed using traditional design methods [4]. Similarly, reductions in rework costs of 20–30% have been documented in projects where BIM-based clash detection was systematically applied throughout the design development phase [6].

In the Russian construction context, the mandatory introduction of BIM requirements for state-funded construction projects, established by Government Decree No. 331 of March 2021, has accelerated the adoption of information modeling practices and created a regulatory framework supporting the transition toward reduced error rates at the national level [5].

Conclusions

The analysis conducted in this study confirms that BIM technologies constitute a highly effective instrument for reducing the frequency and impact of design errors in construction projects. The mechanisms of centralized data management, automated clash detection, parametric change propagation, and structured interdisciplinary coordination collectively address the principal causes of project inaccuracies that characterize traditional design workflows.

The available quantitative evidence demonstrates significant reductions in both the number of design conflicts and the associated rework expenditure in projects where BIM has been systematically implemented. These findings support the conclusion that the adoption of BIM is not merely a technological upgrade but represents a fundamental improvement in the quality management of construction project design.

For first-year students specializing in civil engineering and construction management, an early understanding of BIM principles is of considerable practical importance, as proficiency in information modeling is rapidly becoming a baseline professional competency in the contemporary construction industry.

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INFLUENCE OF OIL ON THE GROWTH AND DEVELOPMENT OF FIBER FLAX SEEDS (*LINUM USITATISSIMUM* L. F. *ELONGATA*)

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Abstract: This article examines the influence of petroleum products on the vegetation of common flax (fiber flax), cultivar Universal (*Linum usitatissimum* L. f. *Elongata*), and is also devoted to the effect of petroleum products on the physical properties of soil. Soil was polluted with crude oil from the Romashkinskoe oil field (Almetyevsk, well 2341) at concentrations of 1%, 3%, and 5%, and with diesel fuel at a concentration of 3%. The study considered the correlation between increasing hydrocarbon content and the changes observed in seedlings. The article presents comparative data on seed germination in uncontaminated soil and in soil contaminated with oil and diesel fuel. Data are given on the effect of oil and diesel fuel in the soil on the early stages of plant development, on geotropism, and on the morphology of fiber flax shoots. The impact of petroleum products as a stress factor is noted.

Keywords: oil, plants, growth, hydrocarbons, diesel fuel.

ВЛИЯНИЕ НЕФТИ НА РОСТ И РАЗВИТИЕ СЕМЯН ЛЬНА- ДОЛГУНЦА (*LINUM USITATISSIMUM* L. F. *ELONGATA*)

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Аннотация. В статье рассмотрено влияние нефтепродуктов на вегетацию растения льна обыкновенного (долгунца), сорт Универсал (*Linum usitatissimum* L. f. *Elongata*), также данная статья посвящена влиянию нефтепродуктов на физические свойства почвы. Было проведено загрязнение почвы нефтью Ромашкинского нефтяного месторождения (Альметьевская, скв. 2341) (содержанием в 1%, 3% и 5%) и дизельным топловом (содержанием в 3%). В ходе исследования рассматривалась корреляция между увеличением содержания углеводородов и изменениями, наблюдающимися у проростков. В статье приведены сравнительные данные по всхожести семян на обычной почве и на почве, загрязненной нефтью и дизельным топливом. Приведены данные по влиянию нефти и дизельным топливом в почве на ранние стадии развития растений, на геотропизм, морфологию побегов льна-долгунца. Отмечено влияние нефтепродуктов, как стрессового фактора.

Ключевые слова: нефть, растения, рост, углеводороды, дизельное топливо.

Introduction. Over the past 60 years, there has been an increase in the level of oil production and consumption. In the course of these processes, leaks occur that lead to the penetration of hydrocarbons into the environment and, accordingly, to the pollution of water and soil [1]. Various methods are used to eliminate accidents, including:

– water purification: installation of boom barriers, filtration, absorption of oil by floating sorbents;

– purification of the surface soil layer: spraying of dispersants (surfactants, powders), use of vacuum pumps.

In recent years, studies have been conducted in the field of using biological resources to clean biocenoses: development of bacterial and fungal strains and plant varieties for the uptake and decomposition of hydrocarbons [7].

Some flax cultivars can be used for soil reclamation due to their ability to extract hydrocarbons. The advantages include low uptake of soil nutrients, low seed cost, and effective removal of pollutants.

The goal of the research work is to record morphological changes associated with soil contamination by oil and diesel fuel. Before the experiments were carried out, the following changes were hypothesized:

- decreased growth;
- reduced development of vegetative organs;
- decreased seed germination.
- Before setting up the experiments, the following objectives were formulated:
- to analyze the effect of oil and diesel fuel contamination on seedlings;
- to identify the causes underlying the observed changes;
- to perform cytological analysis of plant cells in the experiment.

Materials and methods. Oil (Romashkinskoe oil field, Republic of Tatarstan), diesel fuel (Romashkinskoe oil field, Republic of Tatarstan), 120 seeds of common flax, fiber type, soil substrate, and 12 containers for seed germination were used to hold the research.

In the course of the study, four contamination variants with different contents of petroleum products in the soil were established: oil concentrations of 1%, 3%, and 5%, and diesel fuel at 3%. Each treatment was replicated four times. The experiment was laid out on 14/11/2025.

For 1% oil contamination, 1.2 ml of oil and 60 ml of hexane were used per 100 g of soil; for 3% oil contamination, 3.5 ml of oil and 60 ml of hexane per 100 g of soil; for 5% oil contamination, 6 ml of oil and 60 ml of hexane per 100 g of soil. For 3% diesel fuel contamination, 3.5 ml of diesel fuel and 60 ml of hexane were applied per 100 g of soil.

After treatment, the soil became so coated with oil that, during watering, the water did not wet the soil but either flowed out through the slots in the bottom of the container or remained as droplets on the surface without penetrating into the soil [2].

Three days after the start of the experiment (17/11/2025), the first seedlings appeared. From 18/11 to 19/11, active plant growth was observed. On day 12 (29/11/2025), all 20 plants had emerged in all vessels with 1% oil.

Figure 1. Sample germinating power.

Results of the research. In the variant with 1% oil contamination, the plants differed greatly in both growth and development; some plants were severely depressed,

and spots appeared on the cotyledon leaves of some seedlings. In the remaining groups, 100% germination was not observed.

The earliest seedlings were recorded in containers with diesel fuel, but subsequently root protrusion from the soil to the surface was noted; some plants emerged with disturbed geotropism, with the root oriented above the soil and the shoot directed into the soil, or the shoot failed to form. On day 6, one plant died.

On day 12 (26/11/2025), 100% germination was not observed in any of the treatments. Although seedlings initially appeared more rapidly in soil contaminated with petroleum products, subsequent development proceeded more slowly and with pronounced abnormalities. Very rapid emergence in this case is more likely an indicator of the seed response to stress factors, or possibly petroleum products, forming a film on the soil surface, provided some seeds with access to droplets of water accumulated in one place. Once in a zone with sufficient water, the seeds germinated quickly, whereas other seeds in this group did not germinate even by day 14, apparently because they were cut off from access to moisture. In the control group, uniform seedling emergence was observed, and almost all seeds germinated between days 5 and 8.

In containers with 5% oil content, the number of seedlings on day 12 exceeded that in the control, but the plants were elongated, the first cotyledon leaves did not unfold, further leaf formation did not occur, and only stem elongation was observed, which likely indicates a high level of stress.

In the samples with diesel fuel, root protrusion from the soil to the surface was noted, and some plants emerged with disturbed geotropism: in some plants, the root appeared above the soil while the shoot grew into the soil. On day 14, three plants were removed from the soil for measurements and analysis. In Figure 2, we can see strong differences in growth and shoot development between the control group and the contaminated soil group. Although fiber flax in soil with diesel fuel emerged earlier, the shoot length did not exceed 4–4.5 cm, whereas shoots in the control group reached 17–18 cm. In the control group, the shoots had already proceeded to the stage of forming the first true leaves and active elongation, while plants growing in contaminated soil remained at the cotyledon stage. The stem was thickened, and the plants appeared to be “stuck” in this phase of development.

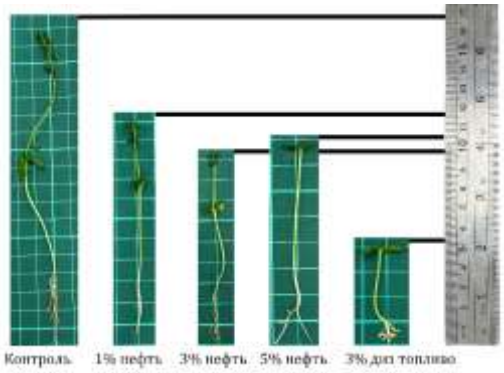

Figure 2. Sample comparison.

Conclusion. Thus, we can see that oil and petroleum products provide an initial boost at germination, with plants emerging faster, apparently due to stress conditions, but further plant development slows down, with delayed transitions between growth phases, disturbed geotropism, the appearance of black spots on leaves, and, in some cases, subsequent plant death. It is planned to carry out cytological studies to understand the effect of hydrocarbons on plant organ cells, the formation of leaf spots, and to determine the stress level in quantitative terms of key physiological indicators.

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THÉORIE DE L'ÉVOLUTION ET UTILISATION DES RESSOURCES NATURELLES

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Résumé : Cet article explore l'interdépendance entre l'écologie et l'évolution, en s'appuyant sur l'histoire du darwinisme et l'idée d'un équilibre naturel dynamique. Il met en évidence la formation de la biodiversité à tous les niveaux – intra- et interspécifique ainsi qu'au niveau de la biosphère – grâce à l'action combinée de facteurs internes et externes. Le texte souligne l'importance des unités évolutivement significatives (populations) pour comprendre les processus de long terme, et décrit comment l'élevage et la sélection des cultures humaines ont façonné une immense diversité biologique. Il introduit la notion de coévolution comme évolution conjointe des espèces et présente le concept de stabilité des ressources et de durabilité écologique, ainsi que le phénomène de « décalage évolutif » qui peut menacer les espèces face au changement climatique. Enfin, l'article propose des stratégies de conservation à l'échelle locale, nationale et internationale visant la protection des écosystèmes, des espèces et du génome, tout en rappelant leur lien indissociable avec le développement socio-économique et la sécurité alimentaire future.

Mots-clés : l'écologie, l'évolution, biodiversité, biosphere.

ТЕОРИЯ ЭВОЛЮЦИИ И ИСПОЛЬЗОВАНИЕ ПРИРОДНЫХ РЕСУРСОВ

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Аннотация. Эта статья исследует взаимозависимость между экологией и эволюцией, опираясь на историю дарвинизма и идею динамического естественного баланса. В ней подчеркивается формирование биоразнообразия на всех уровнях – внутривидовом,

межвидовом и на уровне биосферы – благодаря совместному действию внутренних и внешних факторов. Текст подчёркивает важность эволюционно значимых единиц (популяций) для понимания долгосрочных процессов и описывает, как разведение и отбор культур, применяемые человеком, сформировали огромную биологическую разнообразность. В нём вводится понятие коэволюции как совместной эволюции видов и представлена концепция устойчивости ресурсов и экологической устойчивости, а также феномен «эволюционного лага», который может угрожать видам в условиях изменения климата. В конце статья предлагает стратегии сохранения на региональном, национальном и международном уровнях, направленные на защиту экосистем, видов и генетического фонда, при этом подчёркнуто их неразрывную связь с социально-экономическим развитием и будущей продовольственной безопасностью.

Ключевые слова: экология, эволюция, биоразнообразие, биосфера.

La liaison entre l'écologie et l'idée évolutive, et plus précisément avec le darwinisme, a été proclamée dès les premiers pas de cette science ; en réalité, sa base théorique s'avérait le plus souvent constituée par les conceptions du « équilibre naturel mobile » qui remonta à Spencer. Ce n'est qu'à partir des années 1920–1930 que les éléments de l'approche darwinienne ont commencé à apparaître dans les travaux de ces rares chercheurs qui, en étudiant la distribution et la dynamique des organismes de différentes espèces, essayaient de comprendre les mécanismes généraux assurant l'existence durable des populations. Plus tard, au milieu des années 1950, les premières tentatives d'examiner le cycle de vie des populations (en particulier la distribution par âge de la probabilité de mortalité et de reproduction des individus) comme le produit de la sélection naturelle visant à maintenir le niveau d'adaptabilité nécessaire ont été entreprises [4].

Grâce à l'action et à l'interaction des facteurs allogènes (extérieurs) et autogènes (internes) dans les écosystèmes, s'est formée une diversité biologique à des niveaux intra-spécifiques, interspécifiques et au niveau de la biosphère. La base de la stabilité de la biosphère (ou de l'écosphère) est la diversité de ses écosystèmes constitutifs. La biodiversité à l'échelle globale est soulignée par le soi-disant gradient de la diversité latitudinale — à mesure que l'on se rapproche de l'équateur, le nombre total d'espèces de vertébrés, d'invertébrés et de plantes augmente dans tous les types d'écosystèmes. Cette biodiversité s'est formée à la suite d'une longue évolution de la biosphere [2].

Entre l'espèce et l'individu se trouvent des niveaux intermédiaires spéciaux d'organisation biologique — les populations. Les tâches de conservation à court terme peuvent être résolues au niveau d'unités de gestion individuelles — les stades, mais pour résoudre des problèmes à long terme, il faut travailler avec des objets plus vastes — des « unités évolutivement significatives ». Les unités évolutivement significatives possèdent des jeux d'adaptations uniques dont la perte réduit inévitablement la diversité génétique, la viabilité et le potentiel évolutif de l'espèce [5].

Les exemples les plus parlants des effets de l'homme sur le processus évolutif des espèces sont l'élevage des animaux et la sélection de variétés de plantes cultivées. Ce processus se poursuit de manière ciblée pendant au moins 70 000 ans. La variabilité génétique existante a été utilisée pour dériver des milliers de variétés de plantes et de

races d'animaux. Ainsi, l'homme a créé une énorme diversité d'organismes qui ne pourrait pas être obtenue naturellement et exister dans un environnement naturel.

Les formes ancestrales de nombreuses cultures ont disparu de la face de la Terre. Beaucoup d'espèces d'aujourd'hui diffèrent tellement des formes initiales qu'elles peuvent déjà être considérées comme de nouvelles espèces d'origine anthropique.

Une utilisation rationnelle des ressources végétales n'est pas possible sans la protection des centres d'origine des plantes cultivées.

Les ancêtres sauvages du blé, du riz et du maïs possèdent des gènes de résistance à la sécheresse et aux ravageurs perdus au cours de la sélection.

La conservation de ces réserves évolutives génétiques est la garantie de la sécurité alimentaire du futur.

La coévolution est une évolution conjointe des espèces biologiques qui interagissent dans un écosystème. Des changements touchant des traits des individus d'une espèce conduisent à des changements chez une autre ou d'autres espèces [1].

La notion de coévolution a été introduite par N. V. Timofeïev-Ressovski en 1968. Applicabilité à la nature et à la société, la coévolution propose un développement qui ne détruit pas la stabilité de l'environnement (biosphère) et crée les conditions nécessaires au développement de la société dans le cadre d'un ensemble déterminé de prohibitions et d'impératifs écologiques.

La stabilité des ressources (durabilité écologique) est la capacité d'un écosystème à conserver sa structure et ses caractéristiques fonctionnelles sous l'influence de facteurs externes et internes.

La stabilité des écosystèmes ne peut être maintenue si la loi de l'équilibre dynamique interne est violée. La menace pesant sur la qualité de l'environnement naturel n'est pas seulement une question de ressources, mais aussi l'existence de l'ensemble des composantes naturelles à long terme [3].

Pour assurer la stabilité des ressources, il faut par exemple :

- Optimiser l'utilisation des ressources — mobiliser des éléments renouvelables, accroître l'efficacité énergétique, réduire la consommation.
- Ne pas épuiser les ressources au-delà de leur capacité de régénération.
- Atténuer les effets négatifs de l'impact sur l'environnement, par exemple en réduisant les émissions de gaz à effet de serre et en renforçant la résilience face aux problèmes liés aux chocs climatiques.

Les organismes vivants s'adaptent au changement climatique, mais il existe aussi le concept de « décalage évolutif », lié au fait que l'adaptation d'une population d'une espèce qui s'est autrefois avérée être la meilleure devient avec le temps moins adaptée en raison du changement environnant. Cela peut conduire à l'extinction d'une espèce si celle-ci ne peut pas s'adapter assez rapidement.

Le concept de « décalage évolutif » est lié au fait que l'évolution prend de nombreuses générations, et si une espèce ne peut s'adapter rapidement assez, la population peut manquer de temps pour une adaptation durable. Par exemple, en raison de la fonte des calottes polaires, les adaptations auparavant favorables des ours blancs

deviennent obsolètes, et ils ne s'adaptent pas assez rapidement aux nouvelles conditions. Dans ces régions, la température augmente, ce qui fait que l'excès de fourrure et de graisse devient plus problématique qu'avantageux.

Les stratégies de gestion des ressources pour la conservation de la biodiversité comprennent des mesures de protection des écosystèmes, des espèces et de la diversité génétique, ainsi que des pratiques d'utilisation durable des ressources naturelles. Ces stratégies peuvent être internationales, nationales ou régionales, et inclure des recherches scientifiques.

La stratégie de conservation de la biodiversité est étroitement liée aux stratégies de développement de tous les autres secteurs du pays — économie, sécurité nationale, santé, droit, éducation, science, culture.

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INTRODUCTION DE LA TECHNOLOGIE 3D DANS LE GÉNIE INDUSTRIEL ET CIVIL

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Résumé : Ce travail est consacré au problème de l'évaluation de l'efficacité de l'impression 3D par rapport aux méthodes traditionnelles de construction d'ouvrages de génie civil. **L'actualité de ce travail** ne laisse aucun doute puisque le secteur de la construction cherche constamment à accélérer les processus, à réduire les coûts et à minimiser l'impact environnemental, et l'impression 3D apparaît comme une solution potentielle pour relever ces défis. **Le but** de cette étude est d'analyser les capacités de l'impression 3D de bâtiments en tant que méthode innovante pour le secteur du bâtiment et des travaux publics (BTP). **L'objet de l'étude** est le processus de construction d'ouvrages de génie civil utilisant la technologie d'impression 3D. **Les principaux objectifs** de l'étude sont d'identifier les barrières technologiques limitant l'adoption de cette méthode et d'évaluer son potentiel d'intégration dans la construction industrielle et civile à grande échelle. **Les résultats** de l'étude sont formulés : malgré des limitations techniques et réglementaires actuelles, l'impression 3D offre des avantages significatifs en termes de vitesse d'exécution, de liberté architecturale et de réduction des déchets de chantier. Avec le développement des matériaux et l'adaptation des cadres normatifs, cette technologie pourrait devenir une alternative compétitive aux méthodes classiques dans un avenir proche.

Mots-clés : ouvrages de génie civil, barrières technologiques, bâtiment et travaux publics.

ВНЕДРЕНИЕ 3D-ТЕХНОЛОГИЙ В ПРОМЫШЛЕННОЕ И ГРАЖДАНСКОЕ СТРОИТЕЛЬСТВО

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Аннотация: Данная работа посвящена проблеме оценки эффективности 3D-печати по сравнению с традиционными методами строительства объектов капитального строительства. Актуальность этой работы не вызывает сомнений, поскольку строительный сектор постоянно стремится ускорить процессы, снизить затраты и минимизировать воздействие на окружающую среду, и 3D-печать представляется потенциальным решением для решения этих задач. Целью данного исследования является анализ возможностей 3D-печати зданий как инновационного метода для сектора промышленного и гражданского строительства (BTP). Объектом исследования является процесс строительства объектов капитального строительства с использованием технологии 3D-печати. Основными задачами исследования являются выявление технологических барьеров, ограничивающих внедрение этого метода, и оценка его потенциала для интеграции в крупномасштабное промышленное и гражданское строительство. Результаты исследования сформулированы следующим образом: несмотря на существующие технические и нормативные ограничения, 3D-печать предлагает значительные преимущества с точки зрения скорости выполнения работ, архитектурной свободы и сокращения отходов на строительной площадке. С развитием материалов и адаптацией нормативных баз эта технология может стать конкурентоспособной альтернативой классическим методам в ближайшем будущем.

Ключевые слова: объекты капитального строительства, технологические барьеры, промышленное и гражданское строительство (сектор строительства и общественных работ), 3d-печать, аддитивные технологии.

L’industrie de la construction, pilier de l’économie mondiale, est traditionnellement considérée comme conservatrice en matière d’innovation. Cependant, la pression croissante pour réduire les délais de construction, les coûts et l’empreinte écologique des bâtiments pousse le secteur à explorer de nouvelles méthodes. Parmi celles-ci, l’impression 3D, ou fabrication additive, appliquée au bâtiment (souvent désignée par l’acronyme 3DCP pour «3D Concrete Printing») suscite un intérêt considérable . Cette technologie, qui consiste à fabriquer des ouvrages par l’ajout de matière couche par couche à partir d’un modèle numérique, promet de bouleverser les pratiques établies [2].

La technologie d’impression 3D dans la construction a franchi une étape clé ces dernières années, passant de l’expérimentation en laboratoire à la réalisation de projets pilotes concrets à travers le monde. Des exemples notables incluent la construction de maisons individuelles, de ponts et même d’immeubles de bureau. En Russie, comme le notent des experts du NIISM MGSU, la technologie a atteint un niveau de préparation (TRL 6-7) où des imprimantes, des équipes et des projets pilotes existent, mais où un marché de masse n’a pas encore émergé.

L’analyse des projets réalisés et de la littérature fait ressortir plusieurs avantages récurrents de l’impression 3D.

Rapidité d’exécution et réduction de la main-d’œuvre. L’un des atouts majeurs est la vitesse de construction. L’automatisation du processus permet de réduire considérablement les délais. Une habitation de plain-pied peut voir ses murs imprimés en seulement 20 à 30 heures de travail machine, divisant par trois ou quatre le temps de chantier par rapport aux méthodes classiques. Cette rapidité est intrinsèquement liée à une diminution du recours à la main-d’œuvre manuelle pour les tâches répétitives de

maçonnerie ou de coffrage, répondant ainsi à la pénurie de main-d'œuvre qualifiée que connaît le secteur [4].

Liberté architecturale et réduction des déchets. L'impression 3D s'affranchit des contraintes des coffrages, permettant de réaliser des formes géométriques complexes et organiques (murs courbes, structures alvéolées) sans surcoût significatif. Sur le plan environnemental, le procédé est intrinsèquement plus sobre: en déposant la matière uniquement là où elle est nécessaire, les pertes de matériau sont drastiquement réduites. Certaines études avancent une diminution des déchets de béton pouvant atteindre 95%. Cette précision contribue également à une meilleure efficacité des matériaux [5].

Barrières technologiques et limites actuelles

Défis techniques liés au matériau et à la structure. Le principal défi technique réside dans l'intégration des armatures en acier (ferraillage) nécessaires à la reprise des efforts de traction dans le béton. L'impression 3D standard ne permet pas de placer des armatures conventionnelles à l'intérieur des couches de béton frais. Des solutions sont à l'étude (impression de gaines pour insertion ultérieure, ajout de fibres, impression conjointe avec des robots), mais aucune n'est encore mature et normalisée pour un usage courant. De plus, la qualité et les propriétés mécaniques du béton imprimé peuvent varier en fonction de l'orientation des couches, ce qui complexifie le dimensionnement des structures.

Le potentiel de la technologie pour l'avenir du BTP est jugé considérable, à condition que les verrous actuels soient levés.

Optimisation économique à terme. Des analyses de scénarios prospectifs montrent que si une infrastructure industrielle (fabrication d'imprimantes, centrales de mélange dédiées, logistique spécialisée) se mettait en place, la réduction globale des coûts pourrait atteindre 61%. La technologie est d'ores et déjà compétitive sur le segment de la maison individuelle haut de gamme ou pour des projets d'habitat social d'urgence [1].

Innovation matériau et durabilité. La recherche s'oriente vers le développement de nouveaux matériaux imprimables plus durables que le ciment Portland classique. L'utilisation de géopolymères, de terres crues, de fibres de bois locales ou de résidus agricoles (comme dans le projet Tecla en Italie) est activement explorée pour réduire l'empreinte carbone des bâtiments, faisant de l'impression 3D un vecteur potentiel de la transition écologique du secteur [6].

Conclusion

L'impression 3D appliquée au génie industriel et civil ne doit plus être perçue comme une simple curiosité technologique, mais comme une méthode constructive à part entière, porteuse de solutions face aux défis contemporains de la construction. Les résultats de cette étude confirment que ses avantages en termes de vitesse, de liberté de conception et de réduction des déchets sont bien réels et déjà exploités dans des projets pionniers. Cependant, les barrières technologiques, en particulier l'épineux problème du ferraillage et la variabilité des propriétés des matériaux, ainsi que le vide réglementaire, freinent son essor commercial à grande échelle. L'analyse économique

nuancée révèle que si la compétitivité est prometteuse à long terme, elle dépend encore fortement de la structuration de filières industrielles dédiées. L'intégration réussie de l'impression 3D dans le paysage du BTP passera donc par une synergie entre la recherche sur les matériaux, le développement de normes adaptées et la formation des professionnels. Cette technologie a le potentiel de redéfinir les processus constructifs, mais son adoption massive reste conditionnée à la résolution de ces défis multidimensionnels

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ENVIRONMENTAL DNA (eDNA) AS A MODERN TOOL FOR STUDYING THE ECOLOGY OF ANIMALS IN NATURAL BIOCENOSES, URBANOCENOSES AND AGROCENOSES

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Abstract. This article provides a bibliographic analysis of sources describing the use of environmental DNA (eDNA) as a tool for studying the biological diversity of biocenoses and their sustainability. Information on methods for h**arvesting**, isolating, and sequencing eDNA is provided. A promising experimental design is proposed, involving the collection of spider silk from fixed locations within urban development boundaries (urbanocenosis), agricultural crops (agrocenoses), and protected areas (zones of reduced anthropogenic load) for comparative ecological studies of animals using eDNA. A web-collecting frame developed by the author is described.

Keywords: biocenosis, urbanocenosis, agrocenosis, biological diversity, e**cosystem stability**, environmental DNA, methods, experimental design, device

СВОБОДНАЯ ДНК (эДНК) – СОВРЕМЕННЫЙ ИНСТРУМЕНТ ИССЛЕДОВАНИЯ ЭКОЛОГИИ ЖИВОТНЫХ В ЕСТЕСТВЕННЫХ БИОЦЕНОЗАХ, УРБАНОЦЕНОЗАХ И АГРОЦЕНОЗАХ

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Аннотация. В статье проведён библиографический анализ источников, описывающих использование свободной (экологической) ДНК (эДНК) в качестве инструмента для исследования биологического разнообразия биоценозов и их устойчивости. Приведена информация о методах сбора, выделения и секвенирования эДНК. Предложена перспективная схема эксперимента, заключающаяся в том, что для сравнительного экологического

исследования животных с использованием эДНК производят сбор паутины в фиксированных локациях, входящих в границы городской застройки (урбаноценоз), посадок сельхозкультур (агроценоз) и ООПТ (зона сниженной антропогенной нагрузки). Описано устройство разработанной автором рамки для сбора паутины.

Ключевые слова: биоценоз, урбаноценоз, агроценоз, биологическое разнообразие, устойчивость экосистемы, экологическая ДНК, методы, схема эксперимента, устройство

The main threats to the sustainable development of civilization on Earth are associated with habitat destruction and the potential for a global environmental catastrophe. Most scientists agree that these problems are caused by growing anthropogenic pressure on the biosphere. The significance of this threat underscores the urgent need to develop new scientific methods for studying biocenoses and monitoring their sustainability. Ecosystem sustainability is its ability to maintain its structure and functions under external influences, as well as to return to its original state after these influences cease. The primary stabilizing mechanism is biological diversity, which ensures the duplication of ecological functions [1]. Unlike natural systems, anthropogenic ecosystems (urban and agrocenoses) have low sustainability and require a constant input of energy and resources from outside to maintain their condition.

One of the new methods for monitoring biodiversity is the analysis of so-called environmental DNA (eDNA). Environmental DNA (eDNA) is genetic material collected directly from environmental samples (water, soil, ice, or air), rather than from the organisms themselves. Living creatures constantly leave behind “genetic traces” (skin particles, mucus, feces, pollen) during their life cycles [2]. The eDNA analysis method has become revolutionary for biology, as it allows for monitoring biodiversity without the need for direct observation methods, census, or capture of animals. The main areas of application include: 1) the search for rare and invasive species – detection of secretive organisms by trace amounts of DNA in water or soil, 2) metabarcoding – simultaneous identification of multiple taxa in a single sample using high-throughput sequencing (HTS), 3) paleoecology – the study of ancient ecosystems using DNA from permafrost or deep-sea sediments [3].

In this paper, we focus on an approach to studying eDNA using spider silk as primary samples. This is a modern, non-invasive method for monitoring biodiversity, in which the spider silk acts as a passive biofilter, capturing genetic material from the air and the environment [4]. Spider silk has unique properties that make it an effective tool for collecting eDNA: adhesion (stickiness) – spider silk threads naturally attract and retain biological microparticles (fragments of skin, hair, feathers, pollen, fungal spores, as well as particles of animal feces and saliva); ubiquity – spiders inhabit virtually all terrestrial ecosystems (from forests and caves to city parks and zoos); and the value of a source of information – the analysis allows us to identify not only the spider itself and its recent victims, but also vertebrates that were nearby [5]. Studies confirm the high efficiency of this approach: in experiments in forests in France and Australia, spider silk demonstrated superior results compared to soil samples or leaf swabs, providing a higher probability of species detection [6]. The sensitivity of the

method in a deliberately verified artificial community with increased species diversity is indicative: at Perth Zoo (Australia), eDNA analysis from spider silk identified more than 60 vertebrate species, including exotic animals (orangutans, lemurs, giraffes) [4]. The method is valued for its low cost and non-invasiveness; however, it has limitations. For example, wind currents can carry DNA from distant sources (up to 2.5 km), making precise species localization difficult. Furthermore, collecting natural webs deprives the spider of a web, which is especially unacceptable for rare species. The main advantages and disadvantages of using spider silk as a primary sample for eDNA analysis are listed in Table 1.

Table 1. Main advantages and disadvantages of the method

Advantages	Disadvantages and limitations
Non-invasive: it does not require capture or direct contact with animals	**Energy costs for the spider:** collecting natural webs deprives the spider of a web, which costs it a lot of energy to create
Inexpensive: sample collection is simple and does not require expensive air filtration equipment	**Wind influence:** air currents can carry DNA from distant sources (up to 2.5 km), making precise species localization difficult
Wide coverage: it allows simultaneous monitoring of invertebrates, vertebrates, plants and microorganisms	**Low concentration**: vertebrate DNA on spider webs is often present in very low quantities (less than 1% of all reads)

The most critical step in the first stage of the study is high-quality DNA extraction from the sample. The process requires effective destruction of the spider web protein matrix and prolonged lysis of the spider silk protein (spidroin). Analysis of the sources allows us to propose the following composition of the solution for collecting the spider web sample: Tris-HCl (pH 8.0) – 10 mM (medium buffering); EDTA – 100 mM (chelates ions, controls nuclease activity); NaCl – 100 mM (stabilizes the DNA double helix); SDS (sodium dodecyl sulfate) – 2% (weight/volume) (cell membrane lysis and protein denaturation); guanidine isothiocyanate – 2–3 M (a strong chaotropic agent, optional, for maximum preservation). Sodium azide (the most powerful bacteriostatic agent, completely blocking cellular respiration in microorganisms) can be added to the basic composition (Tris, EDTA, NaCl, SDS) as a preservative at 0.02–0.05% (weight/volume). In this case, it is critical to observe safety precautions (the component is highly toxic; handle with gloves and do not mix with acids). After DNA purification, molecular genetic studies are performed to identify species:

1. metabarcoding is the primary method for assessing the entire community. Universal primers are used (e.g., for the 12S rRNA gene for vertebrates or COI for invertebrates) followed by high-throughput sequencing (HTS);
2. qPCR / ddPCR is used for targeted searches for specific species (e.g., rare predators or invasive pests);

3. bioinformatics – the obtained sequences are compared with global databases (GenBank, BOLD) to determine taxonomic affiliation.

This method enables the detection of a wide range of organisms: from fungi and bacteria to large mammals, located within tens of meters of a spider web.

In this paper, we also present the design of a frame we developed for collecting spider webs (Figure 1).

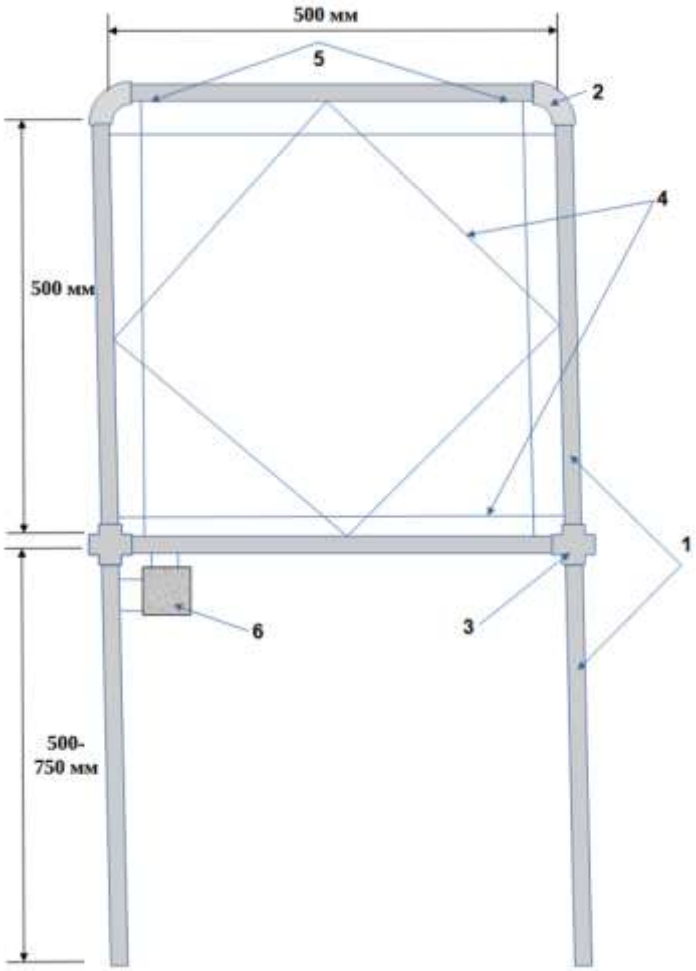

Figure 1. Diagram of a frame for a spider web.
1 – tubes Ø 25 mm; 2 – corner joint; 3 – branch/joint; 4 – nylon fishing line system;
5 – hole on the bottom side of the tube Ø 8–15 mm; 6 – card with a QR code

The frame does not require expensive materials, is easy to assemble, and consists of 25 mm diameter plastic tubes (Fig: 1) connected with standard elements (Fig: 2, 3), a nylon fishing line system for securing the web (Fig: 4), two 8–15 mm diameter holes on the underside of the upper horizontal tube for providing shelter for the spider inside the tube if necessary (Fig: 5), and a card with a QR code linking to the project page, which contains a request not to destroy or damage the frame (Fig: 6). It is proposed to place 3–5 frames at a distance of 10–20 meters from each other in the study locations, strictly oriented north-south (since this is the most common orientation of natural spider webs). It is possible to either wait for the frame to be populated naturally, or to

capture spiders nearby and then place them on the frame. It is recommended to collect the web once every two weeks (as this is the standard time for large web-weaving spiders to use their webs in Central Russia).

The main goal of the planned project will be a comparative analysis of species diversity and the preservation of biocenoses under conditions of maximum anthropogenic load (urban communities, areas of dense urban development, industrial zones, transport traffic, etc.), during work carried out for the benefit of the agro-industrial sector (expressed agrocenoses), and areas with minimal anthropogenic load (protected natural areas, nature reserves). We propose a number of locations for potential project implementation during the 2026–2027 field season in Moscow and the Moscow Region.

Urbanocenoses (Moscow). The locations were selected to assess the impact of dense urban development, transport, and utility systems on the composition of eDNA:

1. Kuryanovsk Wastewater Treatment Plant (KWTP). One of the largest aeration plants in Europe. Spider webs on the technical structures around the open settling tanks accumulate unique eDNA of microorganisms associated with organic waste processing, as well as synanthropic species;
2. Third Transport Ring (Lefortovo Tunnel area). Collecting spider webs on noise barriers and ventilation grilles allows for analysis of the metropolis "air plume." High concentrations of DNA from invasive species and pathogens carried by air currents along major transport arteries are expected here;
3. Moscow-City International Business Center (foundations of high-rise buildings). A unique microclimate with strong vertical air currents. Spider webs here capture eDNA from different layers of the atmosphere, providing a snapshot of urban biodiversity in conditions of extreme urbanization.

Agrocenoses (Moscow Region). The sites were selected for monitoring agricultural pests, pollinators, and the impact of agrochemicals on ecosystems:

1. V.R. Williams All-Russian Forage Research Institute (Lobnya). Experimental fields of forage grasses (peas, rapeseed, barley). The location allows monitoring the population dynamics of pollinating insects and plant pathogens in a controlled agrocenosis;
2. Greenhouse complexes (Lukhovitsy urban district). Spider webs on the external and internal structures of greenhouses serve as an indicator of the penetration of quarantine pests and the status of entomophages used for biological plant protection;
3. Livestock clusters (Volokolamsk urban district). Collecting spider webs near cattle farms allows identifying the DNA of livestock, their parasites, and the microbiome associated with intensive agriculture.

Protected areas and nature reserves (Moscow and Moscow Region). Control points with minimal anthropogenic background for assessing natural biodiversity:

1. Prioksko-Terrasny State Nature Reserve. The only nature reserve in the Moscow Region with a bison population. Spider webs in forested areas here accumulate eDNA of rare forest fauna species, including large mammals;

2. Losiny Ostrov Park (a protected area). The largest forested area within the city limits. It allows for comparison of eDNA profiles of wild animals (elk, wild boar) in close proximity to the metropolis;

3. Terletskaya Oak Forest (Eastern Administrative District, Moscow). A natural monument with relict oaks over 300 years old. The location is important for monitoring the specific microbiota and dendrophagous insects associated with old broadleaf forests.

The bibliographic analysis presented in this paper, the selection of optimal research methods, the proposed sampling scheme (including an original frame for collecting spider webs), and the careful selection of research locations give hope for the successful implementation of this project in the future, especially since this approach to eDNA analysis is currently underused in Russia.

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URINARY MICROBIOTA IN CATS WITH INFECTIOUS CYSTITIS

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Abstract. The results of a retrospective study of the bacterial flora of urine in cats diagnosed with infectious cystitis are presented. An analysis of the species composition of pathogens and their sensitivity to antibacterial drugs of various groups was carried out. The dominance of intestinal microflora, in particular *Escherichia coli*, was established, and high rates of resistance to unprotected penicillins were revealed. Recommendations for the choice of drugs for empirical therapy based on microscopy of urinary sediment are formulated.

Keywords: infectious cystitis, cats, *Escherichia coli*, antibiotic resistance, uropathogens, veterinary microbiology.

БАКТЕРИАЛЬНАЯ ФЛОРА ПРИ ИНФЕКЦИОННОМ ЦИСТИТЕ У КОШЕК

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Аннотация. Представлены результаты ретроспективного исследования бактериальной флоры мочи у кошек с диагнозом инфекционный цистит. Проведен анализ видового состава патогенов и их чувствительности к антибактериальным препаратам различных групп. Установлено доминирование кишечной микрофлоры, в частности *Escherichia coli*, и выявлены высокие показатели резистентности к незащищенным пенициллинам. Сформулированы рекомендации по выбору препаратов для эмпирической терапии на основе микроскопии мочевого осадка.

Ключевые слова: инфекционный цистит, кошки, *Escherichia coli*, антибиотикорезистентность, уропатогены, ветеринарная микробиология.

The pathogenesis of bacterial cystitis in feline patients is primarily associated with the ascending migration of uropathogens from the gastrointestinal tract and the perineal area. *Escherichia coli*, being a commensal of the intestinal microbiota, possesses specific virulence factors, such as P-fimbriae and adhesins, which facilitate its attachment to the urothelium. Once the mucosal barrier is breached – often due to stress, concentrated urine, or local immunosuppression – the bacteria colonize the bladder wall, leading to inflammation and the clinical presentation of dysuria and hematuria [2].

In the context of modern urban veterinary medicine, the management of urinary tract infections (UTIs) is increasingly complicated by the emergence of multidrug-resistant (MDR) strains. While international guidelines, such as those provided by the International Society for Companion Animal Infectious Diseases (ISCAID), recommend amoxicillin or trimethoprim-sulfamethoxazole as first-line choices, clinical reality often differs. In regions like Moscow, the frequent empirical use of unprotected penicillins and cephalosporins has led to a significant shift in susceptibility patterns. This necessitates a more detailed regional analysis of the local microbiota to prevent treatment failures and the further selection of resistant pathogens. The high cost of specialized diagnostics often leads owners to seek cheaper, “trial” treatments, which further exacerbates the selection of resistant strains in the feline population [5].

The study was designed as a retrospective clinical analysis, utilizing the electronic medical database of the “Red Fox” Veterinary Clinic (Moscow). The study period spanned from early 2023 to early 2025. A total of 18 feline patients met the inclusion criteria, consisting of 10 males (55.6%) and 8 females (44.4%). The age of the participants ranged significantly from 1 to 18 years (mean age – 7.4 years), representing various breeds, including British Shorthair, Maine Coon, and Domestic Shorthair.

Inclusion Criteria and Clinical Evaluation

Cats were included in the study if they presented classic symptoms of lower urinary tract disease (LUTD), such as pollakiuria, dysuria, stranguria, or macroscopic hematuria. Each animal underwent a comprehensive physical examination, followed by abdominal ultrasonography using a high-frequency linear transducer (7.5–12 MHz). Ultrasound was utilized to assess bladder wall thickness, detect the presence of uroliths or “sand” (crystalluria), and identify intraluminal debris [3].

Sample Collection (Cystocentesis)

To eliminate contamination from the distal urethra or the genital tract, all urine samples were obtained via ultrasound-guided cystocentesis. The procedure was performed under sterile conditions: the ventral abdominal wall was clipped and disinfected with 70% isopropyl alcohol. A 22-gauge needle was inserted through the bladder wall under real-time ultrasound guidance to aspirate 3–5 ml of urine into a sterile syringe.

Laboratory Analysis and Microbiology

Immediate sediment microscopy was performed in-house to identify the presence of leukocytes, erythrocytes, and bacterial morphologies (cocci or rods) [1]. Subsequently, the samples were transported in specialized sterile containers to the Department of Microbiology and Immunology (RSAU-MTAA) within 4 hours of collection.

Bacterial identification followed standard protocols. Primary inoculation was performed on non-selective Blood Agar and selective MacConkey Agar to isolate Gram-negative enterobacteria. Plates were incubated at 37°C for 24–48 hours. Antimicrobial Susceptibility Testing (AST) was conducted using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar [7]. A panel of 12 antibiotics, representing 6 different pharmacological groups (penicillins, cephalosporins, fluoroquinolones, aminoglycosides, tetracyclines, and phenicols), was utilized to determine the resistance profiles of the isolated uropathogens.

Results and discussion: The analysis of 18 clinical cases of feline infectious cystitis revealed that mono-cultures were isolated in 67% of all urine samples. The predominant pathogen identified during the microbiological screening was *Escherichia coli*, which was found to be responsible for 61% of all confirmed cases as detailed in Table 1. According to the data presented in Table 1, the intestinal microflora, which includes *Escherichia coli*, *Enterococcus faecalis*, and *Enterobacter cloacae*, accounted for 83% of the total infections. These findings suggest that the majority of feline urinary tract infections are associated with the migration of bacteria from the gastrointestinal tract.

Table 1. Species composition of bacterial isolates in feline cystitis.

Pathogen	**Prevalence in all cases**	**Prevalence in females**	**Prevalence in males**
E. coli	61%	75%	50%
Enterococcus faecalis	39%	50%	30%
S. aureus	11%	12,5%	10%
Bacillus sp.	6%	-	10%
Enterobacter cloacae	6%	-	10%
S. aureus (MRSA)	6%	-	10%

The antimicrobial susceptibility profiles for the major isolated uropathogens are illustrated in Figures 1 and 2. A comprehensive evaluation of these profiles indicates significant challenges for standard treatment protocols. Specifically, the highest sensitivity for *Escherichia coli* was observed towards chloramphenicol, reaching 66.7% as shown in Figure 1. However, a critical finding of this retrospective study is the 100% resistance of these isolates to ampicillin, amoxicillin, and cephalexin. This complete resistance to commonly used first-line antibiotics highlights the urgency of revising empirical treatment strategies in urban veterinary practices.

Similarly, the results for Gram-positive isolates provided important therapeutic insights. *Enterococcus faecalis* exhibited 100% susceptibility to amoxicillin-clavulanic

acid, which is depicted in Figure 2. This contrast in susceptibility between different bacterial species underscores the clinical importance of preliminary diagnostics. Based on these results, empirical therapy should be strictly guided by the results of sediment microscopy. For cases where cocci are identified, amoxicillin-clavulanic acid remains a highly effective option, while chloramphenicol or fluoroquinolones are recommended for infections caused by rod-shaped bacteria to ensure a higher probability of clinical success.

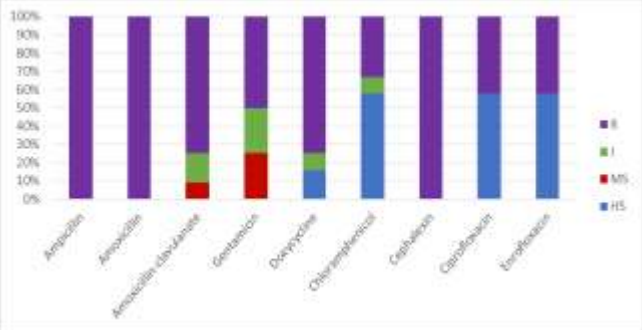

Figure 1. Antibiotic susceptibility of *E. coli* based on 12 culture results

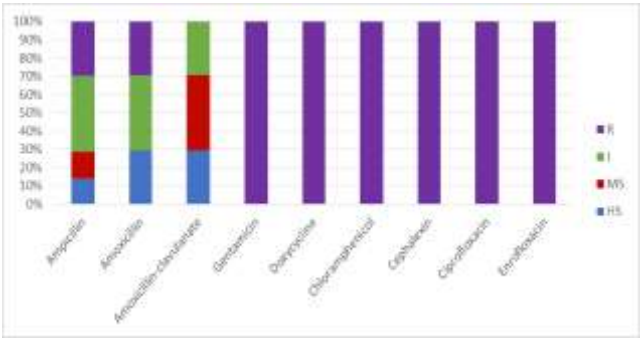

Figure 2. Susceptibility profile of *Enterococcus faecalis*

Conclusion: The retrospective study conducted at the “Red Fox” veterinary clinic provides essential insights into the current microbiological landscape of feline infectious cystitis in Moscow. The findings confirm that Gram-negative intestinal bacteria, primarily *Escherichia coli*, remain the leading cause of bacterial urinary tract infections in cats, representing over 60% of the isolated cases. The high prevalence of these uropathogens underscores the critical role of the intestinal reservoir in the pathogenesis of cystitis and highlights the need for maintaining strict hygiene standards for feline patients.

One of the most significant outcomes of this research is the documentation of a total resistance of isolated *Escherichia coli* strains to unprotected penicillins and first-generation cephalosporins. This 100% resistance rate indicates that traditional empirical approaches using ampicillin or amoxicillin are no longer viable as monotherapies for suspected Gram-negative infections in this region. Such data serves as a serious warning against the indiscriminate use of antibiotics, which has likely contributed to the selection of these resistant strains.

Based on the cumulative findings, we conclude that empirical therapy must be strategically guided by immediate diagnostic tools such as sediment microscopy. This approach allows the clinician to differentiate between bacterial morphologies before the definitive culture results are available. For infections characterized by the presence of cocci, amoxicillin-clavulanic acid remains the recommended drug of choice due to its high efficacy. Conversely, for infections involving rod-shaped bacteria, chloramphenicol or fluoroquinolones should be prioritized to ensure effective clinical management.

Furthermore, the results of this study advocate for a shift in veterinary clinical practice toward mandatory antimicrobial susceptibility testing for all cases of suspected cystitis. While microscopy provides a valuable immediate guide, the high variability in resistance patterns observed in this study suggests that long-term therapeutic success and the prevention of chronic recurrence depend on tailored antibiotic protocols. Future research involving a larger cohort of patients will be necessary to monitor these resistance trends and to evaluate the efficacy of alternative therapeutic agents in the local feline population.

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AUSWIRKUNGEN VON TEMPERATURSTRESS AUF DAS VERHALTEN VON *BETTA SPLENDENS*

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Annotation: In diesem Übersichtsartikel werden experimentelle Daten zum Einfluss von kurzzeitigem Temperaturstress auf das Verhalten von Betta splendens unter Berücksichtigung der ökologischen Besonderheiten der Art (Labyrinthorgan, Anpassung an Hypoxie) zusammengefasst. Es wird gezeigt, dass ein Temperaturanstieg über den Optimalbereich (24–28 °C) hinaus spezifische Veränderungen hervorruft. Ein Absinken auf 22 °C führt zu einer metabolischen Depression, Hypoaktivität und einer Verlangsamung der Verhaltensreaktionen. Ein Anstieg auf 32 °C führt hingegen zu Hyperaktivität, häufigeren Aufstiegen an die Oberfläche und einer Desorganisation des Verhaltensmusters. Die Verwendung von Verhaltensindikatoren zur Überwachung des physiologischen Zustands von Fischen unter Aquarienbedingungen wird begründet.

Schlüsselwörter: Temperaturstress, Verhaltensreaktionen, *Betta splendens*, Zierfischzucht, Aquarium, Fischethologie.

ВЛИЯНИЕ ТЕМПЕРАТУРНОГО СТРЕССА НА ПОВЕДЕНЧЕСКИЕ РЕАКЦИИ ПЕТУШКОВ (*BETTA SPLENDES*)

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Аннотация: В обзорной статье обобщены экспериментальные данные о влиянии кратковременного температурного стресса на поведение *Betta splendens* с учётом экологических особенностей вида (лабиринтовый орган, адаптация к гипоксии). Показано, что выход температуры за пределы оптимума (24–28 °C) индуцирует специфические изменения. Снижение до 22 °C вызывает метаболическую депрессию, гипоактивность и замедление поведенческих реакций. Повышение до 32 °C, напротив, приводит к гиперактивности,

учащению подъёмов к поверхности и дезорганизации поведенческого паттерна. Обосновано использование поведенческих индикаторов для мониторинга физиологического состояния рыб в аквариумных условиях.

Ключевые слова: температурный стресс, поведенческие реакции, *Betta splendens*, рыбоводство, аквариум, этология рыб

Einleitung

Betta splendens (Siamesischer Kampffisch) ist einer der beliebtesten Aquarienfische weltweit, der seit vielen Jahrzehnten nicht nur Gegenstand der massenhaften Zierfischzucht ist, sondern auch als Modellart für verhaltens- und physiologische Untersuchungen dient [9]. Das natürliche Verbreitungsgebiet der Art umfasst Südostasien (Thailand, Vietnam, Kambodscha, Malaysia), wo sie flache, dicht bewachsene Gewässer mit langsamer Strömung bewohnt – Reisfelder, Sümpfe, Straßengräben und temporäre Pfützen. Die Wassertemperatur in solchen Lebensräumen kann während der Fortpflanzungszeit bis zu 31,5 °C erreichen, es sind jedoch auch erhebliche tägliche Schwankungen möglich.

Eine grundlegende Anpassung, die es dieser Art ermöglicht hat, extreme Lebensräume zu besiedeln, ist das Vorhandensein eines Labyrinthorgans – einer oberhalb der Kiemen liegenden, mit Luft gefüllten Struktur, die sich aus dem ersten Kiemenbogen entwickelt. Das Labyrinth besteht aus einem System dünner Knochenplättchen, die von einer stark durchbluteten Schleimhaut bedeckt sind, wodurch die Fische atmosphärischen Sauerstoff aufnehmen und in Wasser mit extrem niedrigem Gehalt an gelöstem O_2 überleben können. Als poikilotherme Organismen sind Fische von der Umgebungstemperatur abhängig, die die Geschwindigkeit der Stoffwechselprozesse, die funktionelle Aktivität der Enzyme und die allgemeine Energiebilanz bestimmt. Trotz ihrer hohen ökologischen Plastizität stellen starke Temperaturabweichungen vom optimalen Bereich für B. splendens einen starken Stressfaktor dar, der eine Reihe von physiologischen und verhaltensbezogenen Veränderungen hervorruft.

Ziel dieser Arbeit ist es, die aktuellen wissenschaftlichen Erkenntnisse über die Auswirkungen kurzzeitiger Temperaturbelastung auf das Verhalten von Betta splendens zusammenzufassen und zu analysieren.

Der optimale Temperaturbereich für die Haltung von Betta splendens im Aquarium liegt laut den meisten Quellen bei 24–28 °C. Die Obergrenze des Komfortbereichs kann bis zu 30 °C betragen, und ein kurzzeitiger Aufenthalt bei 31–32 °C verursacht offenbar keine irreversiblen Schäden. Die Untergrenze der langfristigen Toleranz liegt im Bereich von 20–22 °C, wobei bei Temperaturen von 16,5 °C und darunter bei den Kampffischen ein Gleichgewichtsverlust beobachtet wird [7].

Eine von Leggatt und seinen Mitautoren (2025), zeigte, dass die Fische bei einem täglichen Temperaturrückgang um 1 °C ausgehend von 20,5 °C ihre Fähigkeit verlieren, bei 10 °C das Gleichgewicht zu halten, während Aktivität und Nahrungsaufnahme bereits bei 17,5–16,5 °C deutlich abnehmen. Dies deutet darauf hin, dass in Regionen mit gemäßigtem Klima (einschließlich eines Großteils des russischen Territoriums)

eingeführte Exemplare nicht in der Lage wären, in natürlichen Gewässern zu überwintern.

Es ist jedoch wichtig, zwischen chronischem und akutem Temperaturstress zu unterscheiden [2]. Unter natürlichen Bedingungen hat sich B. splendens evolutionär an einen bestimmten Bereich saisonaler und täglicher Temperaturschwankungen angepasst, doch kurzzeitige, aber erhebliche Schwankungen (z. B. beim Wasserwechsel im Aquarium ohne vorherige Temperaturangleichung) können eine typische Stressreaktion auslösen. Nach heutigem Kenntnisstand umfasst das allgemeine Anpassungssyndrom bei Fischen die Aktivierung der Hypothalamus-Hypophysen-Nebennieren-Achse [1], was zu einem Anstieg des Cortisol- und Katecholaminspiegels führt, sowie die Induktion der Synthese von Hitzeschockproteinen und eine Veränderung der Aktivität metabolischer Enzyme [4].

Interessanterweise können domestizierte Linien von *B. splendens*, die aufgrund ihrer Kampfeigenschaften oder zu dekorativen Zwecken gezüchtet wurden, sich in ihrer Stressreaktivität erheblich von Wildpopulationen unterscheiden. Eine vergleichende Studie von Verbeek et al. (2008) zeigte, dass bei der Kampflinie (Fighter Strain) als Reaktion auf eine ungewohnte Umgebung kein Anstieg des Cortisolspiegels zu beobachten ist, während dieser Wert beim Wildtyp signifikant ansteigt [8]. Darüber hinaus zeigen die selektierten Fische von Beginn der Immobilisierung in der neuen Umgebung an eine Verhaltensstrategie der Bewegungslosigkeit (Erstarrung), während Wildfische nicht auf eine solche Taktik zurückgreifen.

Systematische Untersuchungen zeigen, dass ein Temperaturanstieg im Bereich von 26 bis 30 °C zu einer Zunahme der allgemeinen Bewegungsaktivität der Fische, einer Verkürzung der Zeit bis zum Beginn der Bewegung aus der Startzone und einer Verlängerung der Zeit führt, die in von entfernten Bereichen der Versuchsarena verbracht wird. Diese Veränderungen werden von den Autoren als Anstieg des Parameters „Boldness“ (Mut/Risikobereitschaft) interpretiert, was mit dem allgemeinen Konzept des Zusammenhangs zwischen Stoffwechselrate und Verhaltensäußerungen bei ektothermen Tieren übereinstimmt [5].

Im Gegensatz dazu führt ein Temperaturabfall auf 22 °C und darunter zu einer drastischen Verlangsamung der Fortbewegung, einer Verlängerung der Reaktionslatenzzeit auf äußere Reize und schließlich zu einem Zustand der Erstarrung (Torpor). Bei Temperaturen von 16 °C und darunter verlieren Fische ihre Schwimmfähigkeit und Bewegungskoordination. Dieses Verhalten ist eine Energiesparstrategie: Durch die Verringerung der körperlichen Aktivität minimieren Fische ihren Energieverbrauch unter Bedingungen, bei denen die Stoffwechselrate bereits durch die niedrige Temperatur begrenzt ist.

B. splendens gilt traditionell als eine Art mit einem außergewöhnlich hohen Maß an innerartlicher Aggression, insbesondere bei Männchen, die ihre Schaumnester und Laichgebiete verteidigen. In Laborexperimenten mit dem Spiegeltest oder bei der Präsentation eines lebenden Konkurrenten zeigen die Männchen ein charakteristisches Ritual: Aufblähen der Kiemendeckel, Ausbreiten der Flossen und Ausführen von

Schlägen. Das Ausmaß der Aggression ist jedoch nicht fest vorgegeben, sondern hängt von einer Reihe von Faktoren ab, darunter der Hormonstatus und die Temperatur.

Der Einfluss der Temperatur auf das Aggressionsverhalten ist komplex und nichtlinear [6]. Einerseits fördert die optimale Temperatur (26–28 °C) die volle Entfaltung des Fortpflanzungsverhaltens, einschließlich des Nestbaus und territorialer Demonstrationen. Andererseits können stressauslösende Temperaturschwankungen, insbesondere ein plötzlicher Anstieg, energieaufwändiges Verhalten, einschließlich aggressiver Auseinandersetzungen, unterdrücken. Es wird angenommen, dass Aggressivität ein sensitiver, aber unspezifischer Indikator für den allgemeinen physiologischen Zustand des Fisches ist: Im Stress- oder Krankheitszustand werden ritualisierte Kämpfe durch Trägheit oder, im Gegenteil, durch chaotische Bewegungen ersetzt.

Für Labyrinthfische ist das periodische Einatmen von Luft von der Wasseroberfläche charakteristisch, was bei B. splendens unter normalen Bedingungen mit einer gewissen Regelmäßigkeit geschieht. Die Häufigkeit dieser Auftauchvorgänge hängt von der Temperatur ab, da die Stoffwechselrate und der Sauerstoffbedarf mit steigender Temperatur zunehmen. In einer Reihe von Studien wurde festgestellt, dass die Fische bei 30–32 °C deutlich häufiger an die Oberfläche auftauchen als bei 26 °C. Gleichzeitig sinkt bei 22 °C die Häufigkeit der Atembewegungen (sowohl der Kiemenbewegungen als auch der Auftauchvorgänge), was eine allgemeine Verlangsamung des Stoffwechsels widerspiegelt.

Es ist zu betonen, dass übermäßig häufiges Luftschlucken (mehr als 10–12 Mal in 5 Minuten) in Verbindung mit unruhigem Schwimmen an der Oberfläche ein Anzeichen für Hypoxie oder eine Schädigung des Kiemenepithels sein kann, die sich bei hohen Temperaturen noch verschlimmert. Somit stellt die Überwachung des Atemverhaltens eine einfache und aussagekräftige nicht-invasive Methode zur Beurteilung von Hitzestress dar.

Zusammenfassend lässt sich feststellen, dass sich Temperaturstress bei Betta splendens auf der Verhaltensebene in einer Reihe von regelmäßigen Veränderungen äußert, die sich auf einige wenige Schlüsselsymptome zurückführen lassen:

1. Kältestress (22 °C und darunter) → verminderte Aktivität, verlangsamte Reaktionen, selteneres Auftauchen an die Oberfläche und geringere Flossenbewegungen, Unterdrückung von Aggressionen, Starre.

2. Hitzestress (32 °C und mehr) → Hyperaktivität, häufigere Auftauchbewegungen und Atembewegungen, unkoordiniertes Schwimmen, verminderte Aggressivität (bei gleichbleibender oder sogar verstärkter allgemeiner motorischer Aktivität).

Besondere Beachtung verdient die Tatsache, dass die Stressreaktion zwischen den verschiedenen Linien von B. splendens – Wild-, Zier- und Kampffischen – erheblich variiert. Das bedeutet, dass Empfehlungen zum optimalen Temperaturregime die Herkunft und die Zuchtgeschichte der jeweiligen Population berücksichtigen müssen. So sind beispielsweise domestizierte Formen mit langen Flossen und

leuchtender Färbung in der Regel stressempfindlicher und verfügen über geringere Anpassungsreserven.

Aus praktischer Sicht ist für Aquarianer und Züchter von Zierfischen folgende Erkenntnis am wichtigsten: Die Wassertemperatur sollte so stabil wie möglich im Bereich von 26–28 °C gehalten werden. Selbst kurzzeitige Überschreitungen dieser Grenzen sollten vermieden werden [3]. Beim Wasserwechsel muss die Temperatur des Frischwassers an die des Aquariums angepasst werden (Unterschied nicht mehr als ±1 °C). Bei Störungen der Heizungsanlage sind Verhaltensauffälligkeiten (Apathie, chaotisches Schwimmen, Futterverweigerung, beschleunigte Atmung) die ersten Anzeichen für ein Problem, die eine sofortige Korrektur der Temperatur erfordern.

Schlussfolgerung

In diesem Übersichtsartikel werden die aktuellen Literaturdaten zum Einfluss kurzzeitiger Temperaturstress auf das Verhalten von Betta splendens zusammengefasst. Es wurde festgestellt, dass diese Art eine hohe ökologische Plastizität aufweist und kurzzeitige Temperaturabweichungen vom Optimum (24–28 °C) im Bereich von 22–32 °C verkraften kann; ein Überschreiten dieser Grenzen führt jedoch zu einer Reihe von Verhaltensstörungen. Bei einer Temperaturabsenkung auf 22 °C und darunter dominieren Hypoaktivität, verlangsamte Reaktionen und eine Unterdrückung der Aggression, was eine Energiesparstrategie widerspiegelt. Bei einem Anstieg auf 32 °C und darüber werden Hyperaktivität, häufigere Aufstiege an die Oberfläche und eine Desorganisation des Schwimmverhaltens beobachtet, was auf Sauerstoffmangel hindeuten kann. Verhaltensindikatoren (motorische Aktivität, Atemfrequenz, Aggressivität) sind sensible, nicht-invasive Stressmarker und werden für die Überwachung des Zustands von Fischen in der Aquaristik empfohlen.

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PERMAFROST DEGRADATION: CAUSES AND CONSEQUENCES

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Abstract: Based on an analysis of scientific publications, it is shown that agricultural development of tundra ecosystems (in particular, plowing) accelerates permafrost degradation. The destruction of the natural insulating cover leads to an increase in the depth of seasonal thaw, warming of the permafrost zone, and the activation of cryogenic processes. A conclusion has been reached regarding the irreversible transformation of soil-permafrost conditions, which must be taken into account when developing land use strategies in the Arctic.

Keywords: permafrost, cryolithozone, tundra ecosystems, plowing, seasonal thaw depth, thermokarst, permafrost degradation, geocryological hazards.

ДЕГРАДАЦИЯ ВЕЧНОЙ МЕРЗЛОТЫ: ПРИЧИНЫ И СЛЕДСТВИЯ

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Аннотация: на основе анализа научных публикаций показано, что сельскохозяйственное освоение тундровых экосистем (в частности, распашка) ускоряет деградацию многолетнемерзлых пород. Разрушение естественного теплоизолирующего покрова приводит к увеличению глубины сезонного протаивания, потеплению криолитозоны и активизации криогенных процессов. Сделан вывод о необратимой трансформации почвенно-мерзлотных условий, которую необходимо учитывать при разработке стратегий землепользования в Арктике.

Ключевые слова: многолетняя мерзлота, криолитозона, тундровые экосистемы, распашка, глубина сезонного протаивания, термокарст, деградация мерзлоты, геокриологические опасности.

Modern climate change, characterized by rising temperatures, is having a significant impact on the permafrost zone. However, against this backdrop, anthropogenic impacts, particularly agricultural development, are becoming a powerful additional factor in the destabilization of permafrost. Tundra ecosystems, while possessing some adaptive capacity to natural climate fluctuations, are extremely vulnerable to intense mechanical stress. Research conducted by Yu. Shur and T. Jorgenson shows that two main scenarios for permafrost destruction are possible in response to external influences: a vertical increase in the thawed layer and lateral development of thermal erosion along the edges of disturbed areas. Despite the abundance of model calculations devoted to the response of the permafrost zone to climate change, there is a significant lack of actual observations of the degradation process under different bioclimatic conditions. The aim of this study is to summarize data on the impact of agricultural activity on the thermal regime and soil stability of the tundra, as well as to assess the environmental consequences of intensified cryogenic processes.

Tundra zones occupy a vast area of Russia—over three million square kilometers, or approximately 18 percent of the country's territory. A characteristic feature of tundra cryozems is a layer of ice lying at a depth of one to two meters, which does not melt completely even in the warmest months [3]. The preservation of permafrost in natural conditions is determined by a combination of interrelated factors. Primarily, these are climatic conditions: the warm period lasts only two to three months a year, and summer temperatures rarely rise above 10 degrees Celsius. The hydrological regime of the soils plays a key role, as the impermeable permafrost layer prevents water from infiltrating into the ground layers, but instead lingers in the upper layers, leading to waterlogging and impeding heat exchange [4]. The physical properties of the surface also contribute to the preservation of permafrost: a high albedo significantly reduces the influx of solar radiation—winter snow cover reflects up to 80-90 percent of the sun's rays, while summer moss and lichen cover reflects approximately 30-40 percent. Furthermore, vegetation acts as a natural thermal insulator, limiting soil heating due to the low thermal conductivity of turf, which is only 0.2-0.3 watts per meter Kelvin. Thus, in its natural state, the atmosphere-vegetation-soil-permafrost system exists in dynamic equilibrium, with vegetation acting as a thermostat.

The conversion of tundra soils to cropland initiates a complex of processes associated with the degradation of permafrost through several interconnected mechanisms. The primary cause is the destruction of the natural thermal insulating layer: during plowing, moss-lichen cover and turf are destroyed, significantly increasing the heat flow in the active layer.

The radiation balance is also disrupted: the dark surface of cropland, with an albedo of 10-15 percent, absorbs 70 percent more solar energy compared to 80-90 percent in natural tundra. Changes in the hydrothermal regime are significant:

disturbances to the microrelief and the destruction of soil aggregates lead to moisture redistribution, while a 25-40 percent increase in soil thermal conductivity accelerates the warming of the seasonal thaw layer. An additional factor is the change in the structure of the snow cover: in open areas, a more uniform and dense snow layer forms, possessing pronounced thermal insulating properties, which slows winter freezing and reduces the duration of subzero temperatures in the soil. Taken together, these processes lead to an increase in the thickness of the seasonally thawed layer by 30-80 centimeters in the first 3-5 years of agricultural development, i.e., 1.5-2 times compared to undisturbed areas.

Increased thaw depth causes permafrost beneath cropland to transition from a stable state to an unstable one, and the average annual soil temperature approaches zero degrees Celsius or becomes positive [1]. This triggers a chain reaction of geocryological hazards. Thawing ground ice causes thermokarst—surface subsidence, forming depressions and ponds. On bare and loosened soils, erosion processes intensify significantly: water and wind erosion occur many times faster than under natural conditions [5]. On sloping lands, the plasticity of thawed soils increases, stimulating their downward movement—solifluction. The rate of these cryogenic processes outpaces the rate of vegetation restoration by several orders of magnitude.

Although tundra ecosystems possess some natural adaptive potential to rising soil temperatures and permafrost degradation, which can manifest itself in the replacement of plant communities and the restructuring of biogeochemical cycles, plowing represents such an intensive intervention that it exceeds the ecosystem’s resilience threshold. Natural adaptive mechanisms are suppressed, and the transformation of permafrost conditions directly leads to irreversible soil degradation. Tundra cryozems, characterized by thin thickness and low organic matter content, rapidly lose humus during plowing due to accelerated mineralization. The resulting subsidence and erosion completely destroy the original cryogenic soil structure, making such lands unsuitable for long-term agricultural use. Experimental farming in the Arctic [2], such as at the Polar Experimental Station in the Murmansk Region, confirms that sustainable crop production is only possible with the creation of special artificial substrates in the form of raised beds filled with imported soil mixtures and the use of ultra-early maturing varieties with a growing season of 60-75 days. Potato yields in such systems range from 8-12 tons per hectare, which is 40-60 percent lower than in central Russia, and any expansion of cropland carries the risk of irreversible permafrost degradation.

Based on an analysis of scientific literature, it can be concluded that agricultural plowing in the tundra zone is a powerful catalyst for permafrost degradation. The destruction of the natural insulating cover triggers increased thaw depth, soil warming, and thermokarst activation. These processes are irreversible, as they exceed the natural adaptive capacity of ecosystems. To minimize geocryological risks during the development of northern territories, it is necessary to introduce a ban on continuous plowing of land in areas of icy permafrost, limit farming to a focal method using

technologies that prevent disturbance of the thermal regime of soils, as well as the creation of buffer zones and the organization of continuous geocryological monitoring in areas of any economic impact.

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APPLICATION OF 3D PRINTING FOR CREATING PROSTHETICS AND IMPLANTS IN VETERINARY PRACTICE: INNOVATIONS, CHALLENGES AND PROSPECTS

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Abstract. This article examines the role of 3D printing in veterinary medicine for creating prosthetics and implants. 3D printing allows veterinarians to develop personalized, anatomically precise devices for animals with congenital defects, traumatic injuries, or oncological conditions [1]. The article analyzes the main 3D printing technologies (FDM, SLA, SLS), materials (PLA, ABS, PETG, titanium powders), and clinical cases including a dog named Derby, a cat named Thomas, a sea turtle, horses, and a Nubian goat [2,4,5]. Key advantages include customization, reduced surgical time, lower cost, minimal waste, and improved visualization [1,2,4]. Limitations include high equipment costs, labor-intensive process, difficulties in obtaining quality images, limited biocompatibility, training needs, and ethical concerns [2,5]. The article emphasizes that 3D printing is already transforming veterinary orthopedics, oncology, and reconstructive surgery [4,5].

Keywords: 3D printing, additive manufacturing, veterinary prosthetics, veterinary implants, FDM, SLS, bioprinting, osseointegration, personalized veterinary medicine.

ПРИМЕНЕНИЕ 3D-ПЕЧАТИ ДЛЯ СОЗДАНИЯ ПРОТЕЗОВ И ИМПЛАНТОВ В ВЕТЕРИНАРНОЙ ПРАКТИКЕ: ИННОВАЦИИ, ПРОБЛЕМЫ И ПЕРСПЕКТИВЫ

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Аннотация. В статье рассматривается роль 3D-печати в ветеринарии для создания протезов и имплантов. Технология позволяет разрабатывать персонализированные анатомически точные устройства для животных с врождёнными дефектами, травмами или онкологией [1]. Проанализированы технологии (FDM, SLA, SLS), материалы (PLA, ABS, PETG, титан), клинические случаи: собака Дерби, кот Томас, черепаха, лошади, коза [2,4,5]. Преимущества: индивидуализация, сокращение времени операции, снижение стоимости, уменьшение отходов, улучшенная визуализация [1,2,4]. Ограничения: высокая стоимость оборудования, трудоёмкость, сложность получения качественных изображений, ограниченная биосовместимость, необходимость обучения, этические проблемы [2,5]. 3D-печать уже трансформирует ветеринарную ортопедию, онкологию и реконструктивную хирургию [4,5].

Ключевые слова: 3D-печать, аддитивное производство, ветеринарные протезы, имплантаты, FDM, SLS, биопечать, остеоинтеграция.

Introduction

3D printing has emerged as a transformative tool in veterinary medicine, enabling the creation of customized prosthetics and implants for animals [4]. Traditionally, animals with traumatic amputations, congenital deformities, or tumor-related bone defects had limited options, often leading to euthanasia. 3D printing has changed this paradigm by enabling patient-specific devices that perfectly fit each animal's anatomy [2].

Modern diagnostic systems such as CT and MRI allow realistic visualization of internal structures, providing individual images for each animal [1]. Despite progress, there remains a gap between technological potential and widespread clinical adoption [5].

The aim of this research is to explore the role of 3D printing in creating prosthetics and implants for animals, to analyze clinical cases, and to identify advantages, limitations, and future prospects.

The objectives are:

1. to define 3D printing technology and its basic principles [2];
2. to review current applications [1,4];
3. to analyze clinical cases [2,4,5];
4. to identify advantages and limitations [1,2,5];
5. to discuss future prospects including bioprinting [4,5].

The **object** is the process of creating and implementing 3D-printed prosthetics and implants. The **subject** is the technological, clinical, and educational aspects of 3D printing in veterinary practice. The **theoretical basis** of this study draws on additive manufacturing principles, particularly the concept of layer-by-layer fabrication, as well as clinical case documentation from peer-reviewed veterinary literature [1, 2, 4]. **The practical basis** includes analysis of documented clinical cases, patent materials, institutional reports on 3D printing programs, and technical specifications of available additive manufacturing technologies [3, 5, 6].

Methods and Methodology

This research employs a qualitative case study methodology combined with comparative technological analysis. Primary sources included peer-reviewed

veterinary literature [1,2,4], patent documentation [3], and documented surgical outcomes [5,6]. The analytical framework was structured around three dimensions: technological parameters, clinical outcomes, and practical implementation [2,5].

What is 3D Printing? Definition and Basic Principles

3D printing, or additive manufacturing, builds objects layer by layer from a digital file. Unlike subtractive manufacturing, it results in minimal material waste and enables complex geometries [4].

There are three main technologies used for creating prosthetics [2]:

– FDM (Fused Deposition Modeling) – layer-by-layer creation using melted plastic filament. The most common technology due to accessibility and ease of use;

– photopolymer printing (SLA, DLP, LCD) – used for high-precision parts with smooth surfaces, primarily in dentistry;

– SLS (Selective Laser Sintering) – uses a laser to sinter polymer powder, creating strong, lightweight structures with high accuracy and no restrictions on geometric complexity.

Materials for 3D Printing of Prosthetics and Implants

For FDM printing, various plastics are used: PLA (lightweight, eco-friendly, less durable), ABS (stronger, impact-resistant, elastic), and PETG (close to ABS in strength, flexible, UV-resistant) [2]. For implants, metal 3D printing is used. Titanium powders have high strength and low thermal conductivity. Nickel and zinc materials are also emerging [2].

Veterinary Osseointegrated Implant: Patent Analysis

The utility model “Veterinary Osseointegrated Implant” (Patent RU No. 206864 U1) is used for implantation of an osseointegrated prosthesis in animals [3].

The implant is cylindrical, containing an extraosseous part with through holes for attaching an exoprosthesis and an insertion part with transverse through holes. It is manufactured by printing with titanium powder (Ti-6Al4V) using a 3D model [3].

A plasma calcium-phosphate coating (based on hydroxyapatite) ensures reliable osseointegration – bone tissue ingrowth without fibrous layer formation. An antimicrobial coating based on hydroxyapatite and silver creates an antimicrobial effect in adjacent tissues [3].

3D technologies allow implants to be recreated accurately in size, shape and structure, increasing geometric precision and reducing postoperative recovery time [3].

Clinical Cases of 3D Printing in Veterinary Medicine

Case 1: Dog named Derby (USA, December 2014). 3D Systems successfully fitted a dog named Derby with a 3D-printed prosthesis. The dog suffered from a congenital deformity – absence of front paws and small forearms. Prosthetics allowed Derby to walk freely and even run [4].

Case 2: Cat named Thomas (Novosibirsk, Russia). Veterinarians tested a unique invention on a white cat named Thomas, whose paw was amputated after being caught in a trap. Doctors created 3D bone models, developed drawings, and implanted a titanium prosthesis. The implant completely fused with bone, skin, and muscles. A soft

3D-printed prosthesis was then applied as a basis for growing living cells. For the first time in the world, veterinarians achieved non-rejection of the implant [5].

Case 3: Sea turtle. Veterinary specialists created a jaw for an injured sea turtle. CT scan of the skull was performed, followed by a three-dimensional model and titanium prosthesis of the upper and lower jaws. Using traditional technologies, such a result would be impossible due to the organ size [4].

Application of 3D Technologies in Veterinary Education

3D printing is an effective method for producing accurate anatomical models for veterinary education [1]. Students study and practice on realistic models, gaining better understanding of complex anatomical structures and surgical techniques [1].

Models of internal organs, the circulatory system, and the musculoskeletal system allow visual demonstration of living organism structure and surgical techniques. Students can practice novocaine blockades, fracture fixation, and osteosynthesis, reducing risks during real operations [6].

Limitations and Challenges

Despite its advantages, 3D printing faces several limitations [2,5]:

– high equipment cost – professional printers cost from 10 to 400 thousand dollars, limiting access [2,5];

– labor-intensive process – model creation and printing can take from three days to several weeks [5];

– difficulty obtaining quality images – animal movement, anesthesia risks, and imaging artifacts can affect 3D model quality [5];

– limited biocompatibility – not all materials are biocompatible, potentially causing allergic reactions [2];

– training requirements – special training and experience are needed; few advanced courses exist [2];

– ethical concerns – use of 3D-printed products must not cause harm or unnecessary suffering to animals [5].

Future Prospects of 3D Printing in Veterinary Medicine

Bioprinting, the use of 3D printing to create living tissues and organs, uses a suspension of living cells (bioink) as material [4]. Scientists at 3D Bioprinting Solutions in Russia are developing bioprinters. Successful experiments have been conducted on 3D printing of bones and cartilage [5].

The global 3D printing market grew at an average annual rate of 19.3% from 2014 to 2022, reaching nearly $12 billion. Forecasts suggest $32 billion by 2025 and $60 billion by 2050 [5].

Along the line of educational integration, veterinary schools are incorporating 3D printing into their curricula, preparing the next generation of veterinarians [6].

Discussion and Recommendations

Several practical recommendations for integrating 3D printing into veterinary practice include [1,2,6]:

– veterinary curricula should include introductory training in 3D printing [6];

– institutions should invest in shared 3D printing facilities to reduce costs [5];
– clinical documentation should be standardized to build evidence base [2];
– interdisciplinary collaboration between veterinarians, engineers, and radiologists should be encouraged [3,5].

Conclusion

3D printing is a transformative technology in veterinary medicine, offering unprecedented opportunities for customized prosthetics and implants. 3D modeling is the technology of the future, solving problems not only in medicine but also in research laboratories, and enabling training of students and doctors [1].

However, limitations remain: high costs, training requirements, material questions, and ethical concerns [2,5]. These challenges are surmountable through institutional strategy, investment in education, and continued clinical research [4,5].

Currently, 3D printing in veterinary medicine is not very developed, especially in domestic practice, but thanks to universities and enthusiasts, its application continues to grow [4]. Further research may open new horizons, improving quality of life for animal patients [2].

3D printing is not a futuristic concept. It is an accessible technology already transforming veterinary orthopedics, oncology, and reconstructive surgery [4,5].

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PLANT RESPONSES TO ABIOTIC AND BIOTIC STRESS: A REVIEW OF MOLECULAR MECHANISMS

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Abstract. Plants face many problems. Extreme heat, cold, drought, salt, and heavy metals destroy more than half of all crops every year. Pests and diseases destroy nearly half of the world's food. Scientists are trying to understand how plants protect themselves. This paper looks at two main types of stress: abiotic (non-living factors like weather and salt) and biotic (living threats like pests and germs). The paper reviews the work of many authors. It finds that plants use several connected systems to survive. For abiotic stress, plants send alarm signals using molecules like ROS. They also control potassium levels to manage water loss. For biotic stress, plants use surprising molecules like hydrogen cyanide (HCN) to fight attackers. The paper concludes that there is no single solution to stress. Instead, plants use a network of fast and slow responses. Understanding this network can help scientists grow better crops.

Keywords: abiotic stress, biotic stress, plant defense, reactive oxygen species (ROS), potassium, hydrogen cyanide (HCN), protein modification, sustainable agriculture

РЕАКЦИИ РАСТЕНИЙ НА АБИОТИЧЕСКИЙ И БИОТИЧЕСКИЙ СТРЕСС: ОБЗОР МОЛЕКУЛЯРНЫХ МЕХАНИЗМОВ

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Аннотация. Растения сталкиваются со множеством проблем. Экстремальная жара, холод, засуха, засоление почвы и воздействие тяжелых металлов ежегодно уничтожают более половины всех урожаев. Вредители и болезни уничтожают почти половину мирового продовольствия. Ученые пытаются понять, как растения защищают себя. В данной статье

рассматриваются два основных типа стресса: абиотический (неживые факторы, такие как погода и засоление) и биотический (живые угрозы, такие как вредители и микробы). В статье рассматриваются работы многих авторов. Выясняется, что растения используют несколько взаимосвязанных систем для выживания. При абиотическом стрессе растения посылают сигналы тревоги, используя такие молекулы, как активные формы кислорода (ROS). Они также регулируют уровень калия для компенсации потери воды. При биотическом стрессе растения используют неожиданные молекулы, такие как цианистый водород (HCN), для борьбы с вредителями. В ответ на биотический стресс растения используют неожиданные молекулы, такие как цианистый водород (HCN), для борьбы с вредителями. В статье делается вывод, что единого решения проблемы стресса не существует. Вместо этого растения используют сеть быстрых и медленных реакций. Понимание этой сети может помочь ученым выращивать более качественные сельскохозяйственные культуры.

Ключевые слова: абиотический стресс, биотический стресс, защита растений, активные формы кислорода (АФК), калий, цианистый водород (ЦПГ), модификация белков, устойчивое сельское хозяйство

Introduction

The world's population is growing. The climate is changing. This makes farming very hard. Plants are hurt by two kinds of problems. The first is abiotic stress. This means very high or low temperatures, lack of water, too much salt, and heavy metals in the soil. The second is biotic stress. This means pests, bacteria, fungi, and viruses that attack plants.

Kopecká et al. [1] say that abiotic stress cuts crop yields by more than 50% every year. The FAO says that pests and diseases destroy up to 40% of the world's food. This costs over $220 billion each year. These are not future problems. They are happening now.

Traditional farming uses many chemicals to fight these problems. But Panth et al. [3] argue that chemical pesticides hurt nature and human health. We need better, safer ways to help plants survive. To do this, we must first understand how plants defend themselves at the molecular level.

This paper looks at the work of many scientists. It asks two main questions. First, how do plants deal with abiotic stress? Second, how do plants fight off pests and diseases? The answers can help us grow more food without harming the environment.

Based on the collected articles, I address the following objectives:

1. to examine how metabolic and signaling pathways facilitate plant adaptation to abiotic stress;
2. to analyze the molecular mechanisms of plant defense against biotic stress.

Plant molecular biology has made considerable progress in deciphering how plants sense environmental changes and utilize symbiotic relationships as a sustainable source of biostimulants. Over the past decade, research has centered on improving crop yields through stress tolerance mechanisms, hormone signaling, nutritional optimization, and genome editing.

Regulation of Abiotic Stress Responses

Several authors look at how plants deal with abiotic stress. Kopecká at al. [1] say that abiotic stress (very high or low temperatures, drought, salt, and heavy metals) cuts

crop yields by more than 50% every year. It also lowers the quality of the food we grow. What does this number mean? It means that without better stress tolerance, we already lose half of our possible harvest. And this loss happens even before we count pests, diseases, or bad soil. This is not something that will happen in the future. It is happening right now. Oshunsanya at al. [7] add that when stress lasts a long time, it hurts not only yields but also the overall health of the plant. So, what can we conclude? Even small improvements in stress tolerance could make a big difference in how much food the world can grow.

How do plants survive? One important way, reviewed by Nadarajah at al. [4], is by building up reactive oxygen species (ROS), reactive nitrogen species (RNS), and reactive sulfur species (RSS). At first, this sounds odd. These molecules are known to damage cells. So why would a plant make something harmful? The author explains that low levels of these molecules work as alarm signals. They start a chain of signals inside the plant. These signals get the plant ready for stress. Sevilla at al. [5] point out that the redox regulation system (thioredoxins and glutaredoxins) helps the plant adapt to stress. It also helps different parts of the cell talk to the nucleus and controls which genes are turned on. Here is the main idea: the same molecules that hurt cells at high levels become helpful signals at low levels. The plant has to keep a delicate balance.

There is another issue. Abiotic stress does not just send signals. It also stops plants from moving nutrients around properly. Sandalio at al. [6] show how ROS and RNS control ion channels and transporters in two ways. First, through transcription (making new proteins). Second, through post-translational modification (changing proteins that already exist). Why does this matter? Because changes to existing proteins happen much faster. When a plant suddenly feels heat stress, it cannot wait hours to make new transport proteins. It needs to adjust in minutes. This is why plants use both methods. They work on different time scales.

A good real-world example comes from Xiang J at al. [8]. They show that potassium movements control transpiration. Transpiration affects how well plants handle heat and oxidative stress. Why potassium? Because potassium ions move easily through membranes. They help open and close stomata (the small pores in leaves). When a plant is hot or dry, it closes its stomata to save water. But closing stomata also traps heat and slows down gas exchange. Potassium helps fine-tune this process. So, what is the practical takeaway from Xiang J at al. [8]? Keeping potassium balanced in the plant is a good goal for biotechnology. If we can help plants take up, move, and store potassium better, we can improve both nutrition and stress tolerance at the same time. But there is a problem. Most of what we know comes from a model plant called *Arabidopsis*. Can we simply use the same knowledge for wheat, rice, or corn? The authors say it is time to try. I agree, but with one warning. Different crops grow in different soils and climates. What works for *Arabidopsis* in a laboratory may need changes before it works on a real farm. Still, the basic idea is sound. Keeping potassium balanced is a promising target.

To sum up, it has been shown that abiotic stress tolerance uses several connected systems. These include redox signaling, nutrient transport, and ion balance. The main conclusion is this: there is no single solution for stress tolerance. Instead, plants use a network of responses. Some responses are fast (changes to existing proteins). Others are slower (making new proteins). They also use different molecules (ROS, potassium, and others). Understanding this network is the key to helping crops survive stress.

Regulation of Biotic Stress Responses

Plant diseases are not a small problem. They are a big threat to the world's food supply. Mihajlovic at al. [2] report that microorganisms living in the soil destroy 30–90% of important crops. These crops include wheat, maize, cotton, vegetables, and fruits. Why is the range 30–90% important? It means that for some crops and in some places, farmers can lose almost their whole harvest. The FAO adds that up to 40% of the world's crops are lost to pests every year. This costs more than $220 billion. What can we learn from this? First, even small improvements in how plants defend themselves could save a lot of money and feed many people. Second, globalization and climate change are making the problem worse. Invasive pests can now spread to new areas. In these new areas, local plants have no natural resistance against them.

Why does this matter for molecular biology? Because traditional solutions have serious problems. Panth at al. [3] argue that chemical pesticides harm the natural balance. They kill helpful organisms in the soil. They also hurt human health. So, what is the logical conclusion? We cannot just use more and more chemicals. We need sustainable alternatives. But to create these alternatives, we must first understand how plants defend themselves naturally. We need to look at the molecular level.

Díaz-Rueda at al. [9] present a surprising finding. Hydrogen cyanide (HCN) has long been known as a deadly poison. But it actually works as a signaling molecule. It helps plants fight biotrophic pathogens (pathogens that feed on living tissue). García at al. [10] had already described the mechanism. HCN changes proteins through a process called S-cyanylation. This is a new type of post-translational modification. Why is this important? It completely changes how we think about HCN. For many years, scientists saw it only as a toxic waste product. Now we learn that plants use it on purpose as both a weapon and a signal. The main insight is this: plants can take a poisonous molecule and turn it into a precise tool for defense. This opens new possibilities. If we can understand how plants control the production and signaling of HCN, we may be able to boost this natural defense without causing harm to the plant itself.

To sum up, biotic stress causes huge economic losses and food losses. Chemical pesticides are not a sustainable solution. Natural plant defenses involve unexpected molecules like HCN. New types of protein modifications (like S-cyanylation) are key to these defense pathways. Therefore, future efforts to improve crops should focus on strengthening these natural molecular defenses instead of relying on outside chemicals.

Conclusion

Abiotic stress destroys more than half of the world's crops every year. Biotic stress destroys nearly half. Plants use a network of responses to survive. For abiotic

stress, they send alarm signals (ROS) and control potassium to manage water loss. For biotic stress, they use surprising molecules like hydrogen cyanide (HCN) as weapons. Chemical pesticides are not a good long-term solution. Instead, we should strengthen natural plant defenses. There is no single solution to stress. Understanding the whole network of plant responses is the key to growing more food in a changing climate.

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THE INFLUENCE OF THE AGROECOLOGICAL PROPERTIES OF THE ROSTOV REGION SOILS ON THE DEVELOPMENT AND YIELD OF GRAPES

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Abstract. This paper provides an agroecological assessment of the Rostov region's land suitable for grape cultivation. The analysis is based on comparing the agronomic requirements of the crop and the properties of the soil. The characteristics of the territory, such as the content of organic matter, density, porosity, granulometric composition, sum of positive temperatures, moisture coefficient, precipitation, topography and climate, have been considered. The amount of humus in the southeast of the region was calculated based on the physical and chemical properties of the soil. The optimal agricultural practices for growing grapes in the Rostov region have been analyzed.

Keywords: agroecological land assessment of soil, grapes, humus, porosity, slope steepness, planter plowing and yield.

ВЛИЯНИЕ АГРОЭКОЛОГИЧЕСКИХ СВОЙСТВ ПОЧВ РОСТОВСКОЙ ОБЛАСТИ НА РАЗВИТИЕ И УРОЖАЙНОСТЬ ВИНОГРАДА

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Аннотация. В данной работе была приведена агроэкологическая оценка земель Ростовской области для возделывания винограда. Анализ основывается на сопоставлении агрономических требований культуры и свойств почвы. Рассмотрены такие характеристики территории, как содержание органического вещества, плотность, пористость, гранулометрический состав, сумма положительных температур, коэффициент увлажнения,

осадки, рельеф и климат. Произведён расчёт количества гумуса на юго-востоке области по физическим и химическим данным почв. Проанализирована оптимальная агротехника винограда в условиях Ростовской области.

Ключевые слова: агроэкологическая оценка земель, почва, виноград, гумус, пористость, крутизна склона, плантажная вспашка, урожайность.

The agroecological assessment of the lands of the Tsimlyansky District of the Rostov Region, located on the northern border of industrial viticulture, shows that 99.4% of the territory is used for agriculture. The natural conditions of the region are characterized by gentle slopes (mainly southern), a warm climate with an active temperature sum of up to 3500°C, and insufficient moisture, which meets the agronomic requirements of grapes. The soil cover, which consists mainly of chestnut soils and chernozems, has optimal physical properties for the crop: a light granulometric composition, a density of 1.35 g/cm³, a porosity of more than 50%, and a pH of 5.0-8.7. Light sandy loam soils on slopes with deep groundwater and humus reserves of 100-325 t/ha are the most favorable for successful grape cultivation. Thus, the agroecological properties of the region's soils meet the requirements of viticulture, indicating the high potential for cultivating this crop.

Agroecological land assessment is carried out in accordance with the biological requirements of crops for growing conditions, their environmental impact, and agricultural technologies, which are compared with the agroecological parameters of the primary land plots to determine their suitability for each crop. [1]

In the region (Tsimlyansky district), 99.4% of the territory is used for agricultural production, which indicates favorable conditions for the functioning of agricultural landscapes. The research area is dominated by soils of southern chernozems – 17%, dark chestnut - 38.6%, chestnut – 32.5%, light chestnut – 7.2%, meadow-steppe – 4.7% (in the south-east of the region). Geoinformation analysis showed that the average slope steepness within the boundaries of each field does not exceed 2 degrees, which means that the soils remain unaffected by erosion processes. The predominant land use patterns are those found on the southern (46.1%), southwestern (25.5%), and southeastern (16.9%) slopes of the Tsimlyansky District. The average annual air temperature ranges from 7.9 to 9.3 ℃. The sum of positive temperatures during the active vegetation period is 3200-3500 ℃, and the duration of the period with temperatures >10 ℃ is 175-180 days. The annual precipitation is 322-427 mm, and during the vegetation period it is 180-230 mm. Only a small part of the soil is cultivated, and a lot of water is drained into the ravines. Evaporation exceeds the amount of precipitation and ranges from 260 to 790 mm. The snow cover lasts for 60 to 75 days, but it is quite unstable and has a low thickness. It usually melts in the first ten days of March. During droughts, which occur every 2 to 3 years, there are no rains in the spring and summer. The water content is 0.28 to 0.33% (Kamensky District). The weighted average content of mobile phosphates in the arable layer is within the average and high levels. The amount of humus varies from 2.90% to 2.50% from 1970 to 2016 (Tsimlyansky District). On average, the region has low humus reserves due to

the low humus content of the A horizon (4-5%) and the low profile depth (A + AB), which is about 60 cm. The optimal potassium content in the southeast of the Rostov region is 430-480 mg/kg of soil. The Don River floodplain has slightly acidic and neutral soils. [1,2,4] The parent rocks are loess-like loams and clays. In the valleys of the middle and lower reaches of the Don and the Seversky Donets, there are vast sandy massifs (the Verkhnedonsk and Tsimlyansk sands), on which chernozem-like, poorly differentiated soils of light granulometric composition are formed. The density of the humus profile in the region is 1.30–1.45 g/cm³, the porosity is 45–50%, and the water permeability is good.

The northernmost border of industrial grape cultivation extends to 48° north latitude. This is the land of the Rostov region and the Lower Don region's viticulture. Grapes belong to the arid mesophytes, which corresponds to the climatic conditions of the region. The increased rainfall contributes to the development of fungal diseases, resulting in low-quality grapes with high acidity, which reduces their transportability and shelf life. Grapevines can grow for a long time in the same place, producing full-fledged harvests for 15-20 years or more, so the entire thickness of the soil that is penetrated by the roots is particularly important. The layer of soil in which the absorbing root system develops – the thin and branched roots of the plant – is of great importance. Depending on the type of soil, this layer is located at a depth of 40 to 80 cm. [5] The complex of soil properties, such as structure, thermal, water, and air regimes, as well as physical and chemical characteristics, determines the development of plants, their longevity, active fruiting, the size of the harvest, and its quality. The highest yields with good quality are obtained on well-structured and light soils that are rich in nutrients. As a rule, grape bushes on slopes and sandy soils produce higher-quality grapes than those on flat lands [3]. The best-quality grapes are grown on the southern and southwestern slopes, which are the most common in the Tsimlyansky District of the Rostov Region. During the pre-planting plowing, the upper layers of the soil-forming rock are mixed with the soil. This soil treatment increases the soil's water permeability and moisture content, facilitates the penetration of air and heat into the lower layers, and ensures rapid water absorption. However, when loosening the soil to a depth of 60-70 cm, it is better to move the topmost fertile layer to a depth of 30-50 cm, where the most favorable conditions are created for the development of the main mass of absorbing roots. Light sandy loam or light loamy soils are the most suitable for growing grapes. If the groundwater is close to the surface of the soil (above 1.5 m), the growth of grape bushes is inhibited and they may die, as the root system suffers from a lack of oxygen in the soil [7, 10, 11]. Wines made from grapes grown on soils with low humus content have a high sugar content and a delicate flavor profile. Soils with a humus content of 100 to 325 t/ha guarantee a high yield.

$x = d * h * a$, where d is the bulk weight of the horizon, h is its thickness in centimeters, and a is the percentage content of the element.

$x = 1.35 * 25 * 4 = 135$ kg/ha. is the humus content in the soil of the southeast of the Rostov region.

A fluctuation in humus content relative to the data given may lead to a decrease in yield. The best soils for grape productivity contain 10-55% physical clay, the average soils contain 5-10% or 55-75%, and the worst soils contain less than 5% and more than 75%. When the soil density in the active root zone is up to 1.35 g/cm³ and the total porosity is more than 50%, the yield and productivity of the plant increase. However, when the soil density is up to 1.5 g/cm³, the yield decreases by half, and when it exceeds 1.7 g/cm³, the plant dies. Grapes develop within the pH range of 5.0 to 8.7. [7] The most important factor in creating favorable conditions for the topsoil is the presence of clumpy-grained and granular structures with aggregate sizes of 0.25-10 mm and high porosity (>50%). [8]

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ANALYZING THE IMPACT OF CHEESE ORGANOLEPTIC PROPERTIES ON CONSUMERS PREFERENCES

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Abstract. The research describes the factors influencing the consumers' preferences in cheese selection from an interdisciplinary approach standpoint. It analyzes the relationship between texture, taste and flavor of different cheese types. The paper characterizes the types of cheese produced from different animals' milk. It gives examples of different cheese types. It analyzes the contradictory consumers' relationship to some types of cheese, and their reasons as well.

Key words: taste, flavor, milk, soft cheese, organoleptic properties, semi-hard cheese, consumer's preference, molded cheese, hard cheese, texture.

АНАЛИЗ ВЛИЯНИЯ ОРГАНОЛЕПТИЧЕСКИХ СВОЙСТВ СЫРА НА ПРЕДПОЧТЕНИЯ ПОТРЕБИТЕЛЕЙ

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Аннотация. В данном исследовании описываются факторы, влияющие на предпочтения в выборе сыра потребителями, с позиций междисциплинарного подхода. Анализируются взаимосвязи между текстурой, вкусом, ароматом разных видов сыра. Характеризуются виды сыра, производимые из молока разных животных. Приводятся примеры разных видов сыра. Анализируются противоречивые отношения потребителей к некоторым видам сыра, а также их причины.

Ключевые слова: вкус, запах, молоко, мягкий сыр, органолептические свойства, полутвёрдый сыр, предпочтение потребителя, сыр с плесенью, твёрдый сыр, текстура

Relevance. Our topic is relevant because, firstly, it concerns several scientific disciplines.

The term “influence” used in the formulation of this topic is referred to as “both the process and result of significant changes” [3, p.51]. It means that the factors taken from several sciences inter-influence each other for producing some new outcome that is the mixture from all the factors concerned.

Secondly, cheese studied in this paper is termed as the foodstuff received from both concentration and biotransformation of the main milk components, impacted by enzymes, microorganisms and physical-chemical factors [6, p.4]. This definition attracted us for its high scientific level, as it analyzes cheese production practices.

Food is characterized by the most important human requirements, cheese being one of the most nutritious, varied and delicious foodstuffs that is in many consumers’ demand.

In addition, organoleptic properties are termed as “the response of human senses to the foodstuff properties that enables to obtain rather accurate conclusion concerning food quality without using any measurement tools” [4, p.14]. This analysis is up-to-date, as, on the one hand, it enables a producer to determine the preferences of different consumers, and on the other hand, it enables consumers to choose the best product for them. Therefore, organoleptic properties are known to be the key criteria for understanding consumer preferences, as the product choice is influenced by these properties.

Thirdly, as a consumer is referred to as “the person buying the products in order to satisfy his everyday requirements” [5, p.90], it is possible to study this term from not only food technology, but also from psychological positions.

The next idea that is of importance for our scientific paper is a consumer preference which is known as the selection of both goods and services based on “consumer’s needs, desires, emotional estimates, utility comprehension and composing the readiness to buy either a good or a service” [2, p.75]. Having analyzed this definition, we can see that consumer preferences are subdivided into several groups, including sensation (“consumer needs”) that is followed by mental processes that comprise desires, emotional estimates.

The research purpose, subject, object and tasks. The research goal is to analyze the effect of cheese types as our research subject on its organoleptic properties as the object. The research tasks are to: 1) classify cheeses; 2) consider the ways in which the formation of indicators is influenced by cheese microflora; 3) analyse the consumer cheese preference and the factors that affect them.

The research methods. We have applied different methods in our theoretical and practical research part. The former requires using different kinds of analysis, including both bibliographic and comparative ones. The latter requires survey application.

The research theoretical part. Cheeses are classified according to different criteria, including type, texture, and production technology. Analyzing cheese from

zoo-engineering standpoint, we can come to the conclusion that different farm animals produce different kinds of milk [1]. Cow's milk provides cheeses with both a mild and neutral taste. Goat's milk supplies the piquancy expressed as well as slight sourness for cheeses. Sheep's milk supplies cheeses with a rich, sweet and persistent aroma as well as creamy texture. This is due to different content of fats, proteins, and specific fatty acids in the milk produced by different farm animals.

Being considered from a technological viewpoint, cheeses are classified according to their physical properties. Soft cheeses are characterized by high humidity, creamy texture and delicate taste due to minimal aging and gentle processing. Semi-hard cheeses are of dense but elastic structure, moderate humidity and expressed taste, which have been achieved by cheese mass medium aging and partial pressing. Hard cheeses are characterized by low moisture content, dense structure and pronounced taste, which have been obtained by prolonged aging and pressing.

There are several factors influencing cheese organoleptic properties. The first factor is the production technology. Production technology determines cheese taste, texture, aroma and shelf life directly [7]. The key milk production stages, comprising milk pasteurization, the choice of starter cultures, the temperature and coagulation time, pressing method, maturation duration and conditions from each cheese type uniqueness. For example, long-term exposure enhances both flavor and hardness. The product consistence and safety are influenced by precise humidity control and temperature.

The second factor specified from a microbiological positions is the role of microflora. Microorganisms are of great importance in the formation of organoleptic properties. Forming lactic acid, lactic acid bacteria are able to impart flavor to food. Propionic acid bacteria are capable of affecting both the crust and taste. Molds are able to produce specific taste as well as flavor.

The third factor is cheese flavor. Both milk and creamy flavors are formed due to lactic acid. Dipeptides are produced by lactic acid as well as bacteria. These are young cheese light, fresh notes, mozzarella being an example. Both fruit and floral shades result due to the essential compounds formed during fat and carbohydrate decomposition by microorganisms, esters being an example. Earthy, fungal, and moldy flavors are formed by mold and bacterial metabolites. These are sulfur compounds (such as mercaptans, hydrogen sulfide), ammonia, and other volatile substances that provide both Roquefort and camembert cheeses with their characteristic odor, the former comprising mercaptans and hydrogen sulfides. Sharp, sulfurous and spicy notes result from the protein product decomposition products, especially sulfur-containing amino acids. Both smoked and smoky flavors are formed due to the penetration of volatile phenolic substances into cheese during smoking.

The fourth factor is color, which determines the cheese texture as well as taste. For example, white cheeses are of fresh tastes, examples including both mozzarella and ricotta. Yellow cheeses taste creamy, examples comprising cheddar as well as gouda. These types are semi-hard in texture. Blue cheeses comprising Roquefort as well as

gorgonzola are moldy. Crusted cheeses are of either brown or orange color, examples comprising parmesan as well as taleggio. Both red and pink cheeses have got the crust washed, an example being Munster.

The research experimental part. We conducted our research practical part on the basis of first-year student group No. DT 02-25 studying at the Food Technology Institute of Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, during the 2025-2026 academic year. 15 students participated in our survey dedicated to the correlation between cheese organoleptic properties and consumer preferences. We suppose the product preferences to be influenced by knowledge. For this reason, the students were asked to give examples to each type of cheese as well.

The first question asked was about the preferable type of cheese. Most respondents constituting 9 people or 60% prefer either hard or semi-hard cheeses to consumer, the examples given having included Parmesan, Cheddar, gouda. The subgroup of those preferring soft cheeses (5 people or 33.3 %) predominates over those preferring young brine cheese (1 person or 6.7 %). The examples of the former have included both Edam and Maasdam.

The second question concerns the aspects that are of importance when choosing cheese. Most respondents (14 people or 93.3 %) consider taste to be the most important characteristics when choosing cheese. The number of respondents thinking of composition as the most importance factor (4 people or 33.3 %) is lower than the number of those considering price as the most important factor in cheese selection (4 people or 26.7 %). The lowest number of respondents (2 people or 13.3 %) consider either fat content or producing countries as the most important factors in cheese production.

The third question is the consumer’s attitude to molded cheese. Most respondents (53.3 %) sometimes buy this type of cheese. The number of those who dislike it (33.3 %) predominates over the number of those who have never tasted it (13.3 %).

The fourth question is aimed at understanding the degree of assurance in the molded cheese safety for health. Most respondents (60 %) doubt that this cheese is safe for health. They suppose its safety degree depend on the producing country. The number of the respondents who are more confident than uncertain of this cheese safety degree corresponds to 33.3 %.

Therefore, the aspect affecting cheese preferences belong to different sciences, such as food technology (taste, color), economics (price, producing country) and so on.

The conclusion. Our research is of great theoretical importance, because we have summarized the factors affecting cheese organoleptic properties in our research. Our research is also of practical significance, as it enables a consumer to find cheese according to his preferences.

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GLOBAL TRENDS IN THE ORGANIC FARMING SYSTEM

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Abstract. The article examines the transition to organic farming for ensuring the sustainable development of the agro-industrial complex (AIC) economy. It is shown that the introduction of innovative and environmentally friendly methods of cultivating crop plants into agriculture is a decisive factor in the intensification of crop production and the production of environmentally clean (organic) products. It argues that innovative, eco-friendly crop cultivation methods like biological pest control and some others intensify production while yielding organic products. These reduce chemical use, boost soil health, enhance biodiversity, and cut emissions, addressing global challenges like degradation and climate change.

Keywords: organic farming, organic agriculture, green economy, biological plant protection, biological preparations, organic products.

ГЛОБАЛЬНЫЕ ТЕНДЕНЦИИ В СИСТЕМЕ ОРГАНИЧЕСКОГО ЗЕМЛЕДЕЛИЯ

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Аннотация. В статье рассматриваются проблемы, связанные с необходимостью перехода к органическому земледелию для обеспечения устойчивого развития экономики агропромышленного комплекса (АПК). Внедрение инновационных и экологичных методов возделывания культурных растений в сельское хозяйство является решающим фактором интенсификации растениеводства и производства экологически чистой (органической) продукции. Кроме того, инновационные, экологически чистые методы выращивания сельскохозяйственных культур, такие как биологическая борьба с вредителями и некоторые

другие, интенсифицируют производство, решая при этом проблему получения органических продуктов. Применение данных подходов сокращает использование химических веществ, улучшает состояние почв, увеличивает биоразнообразие и уменьшает выбросы парниковых газов, решая глобальные проблемы, такие как деградация почвы и изменение климата.

Ключевые слова: органическое сельское хозяйство, органическая агротехника, зеленая экономика, биологическая защита растений, биопрепараты, органические продукты.

Introduction. One of the main priorities for the development of the agro-industrial complex over the next 10-15 years is the transition to a green economy and to highly productive, environmentally clean agriculture [9]. All of this is associated with a multitude of factors, in particular with growing environmental problems and the decline in soil fertility, the development of resistance in agricultural pests to chemical pesticides, the residual content of pesticides in crop production, as well as the issue of preserving the rapidly diminishing biodiversity. Considerable pressure on the situation is also exerted by the global market: the organic production of agricultural goods is a mandatory condition for export to many countries of the world. Organic nutrition has today become one of the central themes of our time. Products labeled “eco”, “bio” and “organic” are gaining popularity in Russia, and accordingly, production is growing, making this branch of agriculture very promising [1].

Materials and methods. The research is based on a descriptive-analytical approach that combines international data on organic agriculture with a systematic review of technical and scientific sources on organic farming practices and tools. The materials of the research include:

– data on global and regional areas under organic farming (Europe, Asia-Pacific, Latin America, North America, Russia) from international market and land-use reports;

– information on organic-farming tools and equipment (soil-preparation, sowing, weeding, composting, irrigation, harvesting, and monitoring instruments) from technical manuals, manufacturer descriptions, and extension guides;

– published scientific literature and overviews on ecological agriculture, resistance inducers, entomophages, and microbiological preparations used in organic plant protection;

– national and supranational policy documents related to organic-farming development and targets (for example, EU strategies for increasing the share of organic land by 2030).

Results of the research. As a result of our research, we have identified the following types of tools necessary for the implementation of eco-friendly farming. Organic farming refers to the growing of agricultural crops without the use of mineral fertilizers as well as chemicals, growth regulators and GMO materials [7]. It is a system with a variety of specialized tools and techniques that replace synthetic inputs with mechanical, biological, and ecological alternatives. There are the main groups of tools used in organic farming that can be identified according to the function.

Tools for preparing soil

Good soil preparation is the basic key to organic farming. Because the health of the soil determines the productivity and resilience of a crop. The above-mentioned tools include plows, harrows, rotary tillers, chisel plows, broadforks and others that loosen and structure the soil without synthetic inputs. Farmers within organic systems are increasingly turning to minimum-tillage and no-till options because of their ability to protect the integrity of the soil microbiome, prevent erosion and maintain organic matter levels in the soil. Subsoil tillage implements like the chisel plow are especially used to break up the compacted layers and disturb the upper soil horizon as little as possible so as to not harm earthworms and mycorrhizae.

Tools used for sowing and planting.

In organic systems, sowing at the right time becomes crucial so that the crop competes with the weeds from the beginning itself. Seeding happens with hand seeders, mechanical seeders, planters, and air seeders adjusted for definite placing of organic seed. Most countries' organic certification standards require the use of seed that is certified organic and free of any chemical dressing. With modern precision seeders, variable rate application, proper row spacing and reduced intra-row competition ensure better canopy closure which manages weed emergence naturally.

Tools to control pests and weeds

Fighting weeds and pests is one of the most technically demanding activities in organic production, considering the ban on the use of synthetic herbicides and pesticides. Weeding tools used in organic farming or cropping systems include tine weeders, rotary hoes and flame weeders, mechanical cultivators and mulching equipment. Increasingly, organic farmers use 'weed zappers' or optical-guided precision-cultivation tools. The flame weeding process makes use of the heat produced by propane and it is effective on the young weed seedlings. With the advent of optical and camera-guided inter-row cultivators, managed by GPS or machine-vision systems, farmers can now mechanize weeding within rows with high precision. Notably, the detrimental impact on the crop is very low. These innovations offer new possibilities for serious mechanizations that can significantly reduce the labor intensity of organic weeding, which has been a limiting factor for many years.

Go-to tools for composting to maintain soil fertility

Without mineral fertilizers, the only way to maintain/improve soil fertility is through the organized management of organic matter inputs. The tools in this category are compost bins and piles, compost turners, compost spreaders, manure spreaders, and implements such as shovels, pitchforks, and wheelbarrows to handle organic manures. Compost is a fully decomposed product of plant residues, manure and other organic matter. It is stable and not prone to further microbial decomposition. The compost is used as a nutrient source and soil conditioner. The compost improves the water-holding capacity of the soil and encourages the stability of aggregates in the soil. Going for vermicomposting systems that use earthworms to handle organic waste is becoming popular among smaller organic farmers to create especially nutritious amendments.

Tools for irrigation and water control

The imperative to use water efficiently is present across all agricultural systems; something that is especially relevant to organic production, within which crop stress must be minimal without corrective application of synthetic growth regulators. Systematic and scientific supply of water through drip-irrigation system, hoses, sprinklers, watering cans and water-pumping sets. Subsurface drip irrigation, or SDI, delivers water directly to the root zone and lowers moisture on the surface, which would promote fungal disease development. While these diseases are a problem for all systems, they are especially concerning in organic systems that cannot use synthetic fungicides. Rainwater collection and irrigation scheduling with soil moisture monitoring make organic holdings better water-use efficient.

Tools for harvesting and post-harvesting

Harvesting at the right time and with care is important for losing the minimum but still having good quality products. Such losses tend to have a bigger economic importance in organic production due to the premium prices of the goods. To collect closer to the soil, sickles and shears are most commonly used. In most cases, harvesters and harvest baskets are used for the mechanical harvesting and production farms. The post-harvest handling and the receiving farms will involve a usage of sorting tables, graders, and storage containers. Cold storage and controlled-atmospheric facilities lengthen the shelf life of organic produce without any chemicals post-harvest, which is against the organic certification norms [9]. If hygiene is ensured, less quantity of excess fungi reaches the storage and transport room for spoiling.

Tools for monitoring and precision support

Result-oriented decision making by the organic farmers depends on the timely receipt of correct information. Soil-testing kits, pH meters, thermometers, and growing mobile apps or small drones check the quality of soil and status of crops without using any chemicals. Remote sensing technologies such as satellite based NDVI and UAV operated multispectral cameras can detect the occurrence of nutrient deficiency, pest attack and water stress in large areas soon enough to respond before damage occurs. The use of digital tools in the management of organic farms is regarded as one of the main ways through which the competitiveness of organic and the stability of their yields relative to the conventional could be improved.

The application of these tools and methods is essential for truly environmentally friendly farming, because they allow crop production without relying on synthetic fertilizers, pesticides, or GMOs. By using mechanical tillage, composting, and biological pest control instead of chemicals, organic farming protects soil structure, preserves biodiversity, and prevents water and air pollution. These instruments also support efficient nutrient cycling, improve long-term soil fertility, and reduce the carbon footprint of agriculture [2, 3, 4]. Moreover, precision and monitoring tools help farmers optimize water, compost, and labor use, minimizing waste and environmental impact. In this way, the consistent use of such methods not only ensures safe, organic food but also maintains the natural resource base on which future agriculture depends.

Organic farming is a highly sought-after field that is actively developing and improving. It demonstrates steady growth: in 2025, the area of organic land reached nearly 99 million hectares, and the market exceeded 136 billion euros. The largest increases are in Uruguay, China, and Spain. In Europe, active promotion of ecologically clean product manufacturing is continuously conducted. In Austria, an institution operates (the Research Institute of Organic Agriculture, FiBL) exclusively engaged in this practice. The Asia-Pacific region is the fastest-growing. Today, India leads in the number of organic farmers (1st place in the world). Organic farming is also widespread in France, where approximately 61 thousand farmers across the country are involved in it. The European Union plans to expand the use of land for organic farming from the current 11% to 25% by 2030 [5]. By 2029, further growth is expected due to the narrowing of the price gap between organic and conventional farming products. In Brazil - a country with great potential to become a major agrarian center of South America - «green» farming is also actively developing. Agricultural land specializing in organic farming in Brazil already amounts to more than 600,000 hectares as of 2024, compared to approximately 380,000 hectares in 2015. As of 2023, there were around 26,000 producers engaged in organic agriculture in the country, which is 123% more than in 2015. In North America, in the United States, approximately 2.3 million hectares are already dedicated to organic agriculture. The majority of organic farmers there are small or relatively small-scale producers, and the average size of organic farms is around 15 hectares. The Russian Federation has enormous potential as a producer of environmentally clean products. At now, the organic agriculture sector in Russia is still in its nascent stage. Russian producers undoubtedly have the potential to develop their share of eco-products on the global market. Currently, the area of unused land suitable for organic farming amounts to approximately 12 million hectares. Therefore, it is important for Russia to develop local support programs for agricultural producers in order to utilize the potential of all idle lands.

Scientists around the world are engaged in research dedicated to organic agriculture with the aim of addressing problems of an ecological and social-economic nature. Particular attention today is given to resistance inducers - biologically active substances, biological preparations that regulate plant protection. Resistance inducers do not act directly on the pathogen but instead activate the plant’s own defense mechanisms of its immune system. Such agents do not require intervals between repeated treatments and do not require an increase in dosage, as they do not cause a «habituation» effect in the pathogen. The use of entomophages – natural pest regulators – is one of the promising tools of organic agriculture. Entomophages regulate the population of insects harmful to plants. Today, a large number of entomophage species exist; they are used both in open and closed grounds. In greenhouses, for example, bugs and predatory mites are in demand, intended for the control of spider mites, thrips, whiteflies, and aphids, while in open ground the greatest popularity has been gained by Trichogramma, whose larvae parasitize the eggs of more than 200 species of crop pests. Preparations of microbiological synthesis are also extremely sought after, representing

a safe means of protecting plants against diseases, insect pests, and weeds [8]. The most popular among agricultural producers in the plant protection system are biological preparations based on fungi, extracts of certain plants, and algae [7]. It should be noted that biological preparations demonstrate high effectiveness even under conditions of risky farming - on saline, acidic, and arid soils.

Conclusion. It must be noted that despite the significant growth of organic farming, this field still faces a number of serious challenges. The economic barrier remains relevant; the prices of products grown in this manner remain high due to higher production costs, thereby limiting consumer demand. In addition, the process of certifying ecologically clean products requires a great deal of time and money. The organic farming system also faces production challenges: the yields of many agricultural crops often turn out to be lower compared to their productivity under conventional cultivation. Moreover, this method of farming requires significantly more land resources. Environmental problems also erect their own barriers – soil degradation, loss of biodiversity, and competition for resources impede the development of organic farming in a number of countries around the world. However, such obstacles are surmountable – government subsidies, support measures, and new technologies are helping to reduce costs and increase the yields of cultivated plants.

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ANALYZING THE EFFICIENCY OF USING VISUAL-GRAPHICAL SOFTWARE FOR DRAWING AND MODELLING

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Abstract: Our paper analyzes the efficiency of using different ways of visual-graphical software. It considers the features of software application in different areas. The research analyzes visual-graphical advantages and disadvantages for drawing and modelling. It considers the role of visual-graphical means in providing the conditions for more efficient information comprehension when solving practical tasks.

Keywords: modelling, visual-graphical image, software, drawing, efficiency.

АНАЛИЗ ЭФФЕКТИВНОСТИ ИСПОЛЬЗОВАНИЯ НАГЛЯДНО-ГРАФИЧЕСКОГО ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ ДЛЯ РИСОВАНИЯ И МОДЕЛИРОВАНИЯ

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Аннотация. В статье оценивается эффективность применения разных способов визуально-графического программного обеспечения. Рассматриваются особенности применения наглядно-графического программного обеспечения в разных областях. Анализируются преимущества и недостатки использования визуально-графического программного обеспечения для рисования и моделирования. Рассматривается роль наглядно-графических средств в обеспечении условий для более эффективного понимания информации при решении практических задач.

Ключевые слова: моделирование, наглядно-графическое изображение, программное обеспечение, рисование, эффективность

Relevance. Our research is up-to-date, as, firstly, it is built on several scientific disciplines, that include programming fundamentals, modelling and drawing theory as wells as economic perspectives on technical efficiency.

Secondly, visual-graphical systems are vital, as they satisfy the most essential human requirements, including the need for beauty, cognition fundamentals through visual perception and the drive for professional growth, the former being referred to as aesthetics [1].

Thirdly, we can define software as a set of instructions for data processing [4, c.53]. Meanwhile, drawing is known as the life reflection, using graphical means like either digital pencils or ink in order to represent reality [2, c.88].

Modelling involves creating a simplified replica of either real objects or phenomena. This process lets us obtain new information and forecast behavior when real objects are either too complex or inaccessible [3, c.429].

The research problem. We have specified our main research problem as art-sampling, that is the risk that software might either replace human talent or kill the artistic work emotional depth. As a result, we should balance technical automation with creative expression.

The research purpose, subject, object and tasks. The research purpose is to analyze the ways in which different visual-graphical software packages as our research subject influence the quality of drawing and modelling outcomes specifically for agricultural applications as the object. The research tasks are to: 1) define the performance criteria; 2) specify different performance levels; 3) evaluate the software used in the current agricultural sector according to the algorithm presented.

The research hypothesis. Our research hypothesis is that higher software results in better technical as well as aesthetic outcomes. The software application ease improves both the professional self-realization and perception level.

The research methods. Our research methods include a combination of surveys, mathematical analysis and evaluative methods aimed at comparing the performance of various graphical systems.

The research process and outcomes. The research done by us has classified the programs according to both functionality and purpose. We calculated the software effectiveness degree, based on color depth, the variety of lines, and the ability to convey complex design intentions in order to find the best ones.

This software core application, the Digital Twin, is known to be the farming system replica, continuously updated with real-time data from interconnected sensors as well as devices.

The 3ds Max as well as Unity 3d were used in order to create high-fidelity tea plant models in the first case study. It allows managers to visualize soil moisture as well as make precise irrigation decisions.

In order to manage large-scale visualizations, the LOD technology is applied. It dynamically adjusts rendering quality based on the distance of the camera, ensuring high visual quality without overloading the system.

The research outcomes show that LOD implementation improved the frame rate by 121 %, while the vertex reduction was equal to over 93%. This ensures a stable and responsive user interface.

Another key system is Building Information Modeling that uses Autodesk Revit. It creates accurate 3D models of agricultural buildings in order to improve planning and management. BIM both optimized the concrete usage by 1.35% and provided a total cost of nearly 1%, compared to manual methods.

Like SolidWorks and Creo, computer -aided design software lets the designers visualize and optimize machines, such as rotary tillers, in the screen rather than on paper.

The Finite Element Analysis located within CAD software is used in order to compute stress distribution. This allows to study the ways in which tillage equipment reacts to soil forces before we build a prototype.

3-Point Cultivator Using Siemens NX and ANSYS, as well as 7-tyne cultivator were analyzed. The analysis showed that although stress reached the material yield point, it remained within acceptable limits in order to prevent failure.

Conclusion. Our research is of great practical importance, because it demonstrated that design automation can reduce costs by up to 30% as well as speed up production significantly. Our paper is of theoretical significance, as it demonstrates that integrated visual systems improve the global agriculture sustainability as well as productivity.

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INFLUENCE OF INCREASING MINERAL FERTILIZER DOSES ON CEREAL CROPS

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Abstract: This article presents a comparative analysis of the response of cereal crops to increasing rates of mineral fertilizers based on data from two long-term field experiments conducted on sod-podzolic soils in the Non-Chernozem zone of Russia. The experiments included barley (cv. Abava) and winter rye (cv. Falenskaya 4) and differed in experimental design; therefore, the original data were unified to the scale of fertilizer application rates (N_0–N_{150}) to ensure comparability. The analysis focused on yield, yield increase relative to control, and fertilizer use efficiency. The results showed that crop yield increased with rising fertilizer rates only up to a certain threshold (30–90 kg a.i./ha), after which the response either stabilized or became inconsistent. In contrast, fertilizer use efficiency demonstrated a consistent decline with increasing application rates in both experiments.

Keywords: mineral fertilizers; fertilizer application rates; yield response; barley; winter rye; sod-podzolic soils; long-term field experiment

ВЛИЯНИЕ ВОЗРАСТАЮЩИХ ДОЗ МИНЕРАЛЬНЫХ УДОБРЕНИЙ НА ЗЕРНОВЫЕ КУЛЬТУРЫ

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Аннотация: В данном исследовании представлен сравнительный анализ реакции зерновых культур на возрастающие дозы минеральных удобрений на основе данных двух длительных полевых опытов, проведённых на дерново-подзолистых почвах Нечернозёмной зоны России. В опытах изучались ячмень (сорт Абава) и озимая рожь (сорт Фаленская 4), при этом схемы экспериментов различались; в связи с этим исходные данные были нормированы

к единой шкале доз удобрений (N_0–N_{150}) для обеспечения сопоставимости. Анализ включал показатели урожайности, прибавки урожая относительно контроля и эффективности использования удобрений. Установлено, что урожайность культур возрастала с увеличением доз удобрений лишь до определённого порога (30–90 кг д.в./га), после чего отклик стабилизировался либо становился неустойчивым. В то же время эффективность использования удобрений последовательно снижалась при увеличении доз их внесения в обоих опытах.

Ключевые слова: минеральные удобрения, дозы удобрений, ячмень, озимая рожь, дерново-подзолистые почвы, длительный полевой эксперимент.

Introduction. In modern agroecosystems, crop productivity largely depends on the level of plant nutrient supply, making the optimization of fertilization systems essential. As yields increase, so does the nutrient uptake by plants. However, yield growth remains proportional to fertilizer application only up to a certain level, beyond which economic performance declines [6].

According to researchers, sod-podzolic soils of the northeastern non-Chernozem zone of Russia are characterized by low natural fertility due to limited nutrient availability. The application of mineral and organic fertilizers is therefore a key factor in improving soil fertility, increasing yields, and enhancing product quality. At the same time, fertilizer efficiency depends on application rates, nutrient balance, and environmental conditions, which necessitates a scientifically based approach [3]. Long-term field experiments are considered to be particularly valuable for identifying general patterns of yield formation and determining optimal fertilizer rates [5, 8].

Aim and objectives. The aim of this article is to analyze the effect of increasing rates of mineral fertilizers on cereal crop productivity under sod-podzolic soil conditions. The objectives include the study of the impact of different fertilizer doses on the yield of barley and winter rye, assessment of the changes in fertilizer efficiency depending on application rates as well as to determine optimal fertilizer doses ensuring maximum yield and efficiency, to identify general patterns in the response of crops to mineral fertilization.

Materials and methods. The present study is based on a comparative analysis of the results of two long-term field experiments conducted within the same natural zone, in different regions of the Russian Federation, on the same soil type, and devoted to the study of the effect of mineral fertilizers on the productivity of two cereal crops. The object of analysis included data from a study on the effect of increasing rates and ratios of mineral fertilizers on barley yield and grain quality [2] conducted in the Kirov region, and data from a study on the effect of different rates and ratios of mineral fertilizers on winter rye yield in the Middle Urals [7] conducted in the Perm region. Both datasets were obtained under long-term agrochemical experimental conditions.

The first experiment was carried out on sod-podzolic medium loamy soil in the Kirov region within a six-field grain-fallow-grass crop rotation system. This study was designed as a long-term stationary experiment, including various treatments with mineral fertilizers (nitrogen, phosphorus, and potassium) applied in different combinations and rates. The experimental design represented a subset of a full factorial

scheme and comprised 22 treatments. The experiment was conducted with two replications. Yield assessment was carried out using standard methods, followed by the analysis of yield structure [1, 2, 9]. The second experiment was established within a long-term stationary field trial in the Perm region and conducted under crop rotation conditions. The experimental design consisted of 24 treatments and represented a reduced scheme (1/9) of a full factorial experiment (6×6×6), involving six levels of nitrogen, phosphorus, and potassium fertilizer rates with the dose of 30 kg/ha of active ingredient. Each treatment was done twice, and plots were arranged in a randomized layout. This study paid particular attention to evaluating the effect of increasing nitrogen fertilizer rates on winter rye yield, as well as on fertilizer use efficiency and economic performance [7].

To ensure comparability of results, a method of data unification to the same scale of fertilizer application rates was employed in this study. The following levels were selected as reference points: control - $N_0P_0K_0$; $N_{30}P_{30}K_{30}$; $N_{60}P_{60}K_{60}$; $N_{90}P_{90}K_{90}$; $N_{120}P_{120}K_{120}$; $N_{150}P_{150}K_{150}$. These levels represent a sequential increase in nutrient application rates with the dose of 30 kg/ha of active ingredient and allow the analysis of the data along a single gradient of the “fertilizer dose” factor. The adaptation of the original treatments to this scale was carried out based on the principle of closest correspondence between actual and standardized rates. Within the framework of this study, the following parameters were analyzed: grain yield (t/ha), yield increase relative to the control (t/ha), and fertilizer use efficiency (kg of grain per kg of active ingredient)

Data analysis was carried out with the use of comparative and graphical-analytical approaches. To identify patterns in crop response to fertilizer application, tables (Table 1 and Table 2) were compiled, presenting fertilizer dose treatments, yields of barley (cv. Abava) and winter rye (cv. Falenskaya 4). Yield and efficiency values were calculated as averages over three years for barley and two years for winter rye. In interpreting the results, the principles of the law of diminishing returns were taken into account.

Table 1. Effect of increasing doses of mineral fertilizers on the yield of Abava barley variety and the payback of mineral fertilizers in grain.

fertilizer application rates	yield t/ha	increase	grain return per 1 kg of active ingredient, kg
$N_0P_0K_0$	1.4	-	-
$N_{30}P_{30}K_{30}$	2.44	1.04	11.6
$N_{60}P_{60}K_{60}$	2.92	1.52	8.4
$N_{90}P_{90}K_{90}$	3.41	2.01	7.4
$N_{120}P_{120}K_{120}$	3.35	1.95	5.4
$N_{150}P_{150}K_{150}$	3.61	2.21	4.9

Table 2. Effect of increasing doses of mineral fertilizers on winter rye of the Falenskaya 4 variety and the payback of mineral fertilizers in grain.

fertilizer application rates	yield t/ha	increase	grain return per 1 kg of active ingredient, kg
$N_0P_0K_0$	2.06	-	-
$N_{30}P_{30}K_{30}$	2.48	0.42	4.68
$N_{60}P_{60}K_{60}$	2.41	0.35	1.91
$N_{90}P_{90}K_{90}$	2.29	0.23	0.85
$N_{120}P_{120}K_{120}$	2.52	0.46	1.28
$N_{150}P_{150}K_{150}$	2.28	0.22	0.48

To provide the clarity and comparability of the results, graphical visualization was employed in the form of bar charts (Figure 1, Figure 2) with superimposed trend lines illustrating cereal crop response to increasing fertilizer rates. Vertical axis in Figure 1 and Figure 2 refers to yield and fertilizer application efficiency.

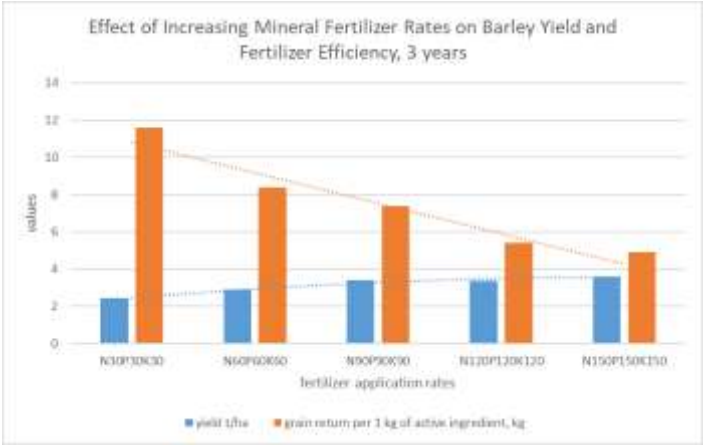

Figure 1. Effect of increasing doses of mineral fertilizers on the yield of Abava barley variety and the payback of mineral fertilizers in grain

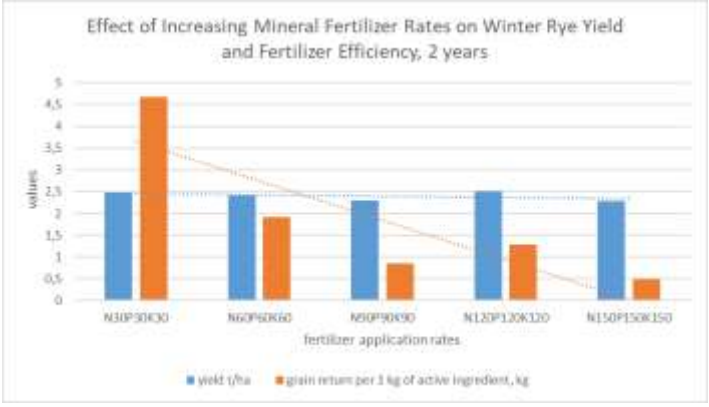

Figure 2. Effect of increasing doses of mineral fertilizers on winter rye of the Falenskaya 4 variety and the payback of mineral fertilizers in grain

Results. In the first experiment (barley, cv. Abava), a clearly pronounced positive response of the crop to fertilizer application was observed at the initial stages

(Figure 1). Yield increased from 1.4 t/ha in the control to 3.41 t/ha at the $N_{90}P_{90}K_{90}$ rate, indicating an intensive growth pattern within this range. With further increases in fertilizer rates (N_{120}-N_{150}), there was yield stabilization with values ranging from 3.35 to 3.61 t/ha. In the second experiment (winter rye, cv. Falenskaya 4), the relationship was less pronounced (Figure 2). The maximum yield (2.48 t/ha) was achieved already at the $N_{30}P_{30}K_{30}$ rate. Further increases in fertilizer application did not result in a consistent yield increase; instead, fluctuations were observed within the range of 2.28-2.52 t/ha. The increase in yield observed at $N_{120}P_{120}K_{120}$ (2.52 t/ha) does not follow the general trend and is not supported by the dynamics at adjacent rates; it is therefore likely attributable to variability in growing conditions [7].

In the first experiment, yield increased steadily up to $N_{90}P_{90}K_{90}$ (1.04 → 1.52 → 2.01 t/ha) and then plateaued (1.95-2.20 t/ha), indicating diminishing fertilizer efficiency at higher application rates. In the second experiment, yield generally declined with increasing fertilizer rates (0.42 → 0.35 → 0.23 t/ha), with a brief deviation at $N_{120}P_{120}K_{120}$ (0.46 t/ha), followed by a decrease at $N_{150}P_{150}K_{150}$ (0.22 t/ha), suggesting an early optimum around lower doses and an unstable response beyond it. A comparison of the two experiments shows that in both cases the maximum yield increase is achieved at low to moderate fertilizer rates. Increasing fertilizer rates beyond these levels does not ensure a stable increase in yield gain and is accompanied by its stabilization or decline. Individual deviations (e.g., at $N_{120}P_{120}K_{120}$ in the second experiment) do not alter the overall trend and are associated with environmental variability [4].

Based on the combined analysis of both experiments, the following patterns were identified: 1) yield increases with rising fertilizer rates only up to a certain threshold (30–90 kg a.i./ha), beyond which the growth slows down or becomes unstable; 2) fertilizer use efficiency shows a consistent decreasing trend as application rates increase, regardless of crop type and experimental conditions.

Conclusion. The obtained results indicate the existence of an optimal range of mineral fertilizer application rates, beyond which their efficiency declines. This confirms the validity of the law of diminishing returns and highlights the need for a scientifically justified approach to nutrient management in agricultural systems, taking into account not only yield levels but also fertilizer use efficiency.

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THE IMPACT OF ANTHROPOGENIC ACTIVITY ON WHALE SHARK (*RHINCODON TYPUS*) EXTINCTION.

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Abstract. Anthropogenic pressure is driving the decline of whale sharks (*Rhincodon typus*), the world's largest fish and an IUCN-endangered species with over 50% population loss in 75 years. This article examines human impacts, including ship strikes (overlapping 92% of shark habitats with shipping lanes), fishery bycatch, ocean pollution (microplastics, heavy metals), unethical tourism, and poaching, and reveals underreported mortalities like sinking post-collision. This study presents practical solutions to combat anthropogenic threats to whale sharks (*Rhincodon typus*), including the introduction of speed limits and changing vessel routes, restrictions on non-ecological tourist cruises. This article highlights the need for personal responsibility of citizens, which contributes to the prevention of unethical tourism (for example, shark feeding, shark fin soup) in order to prevent the maintenance of illegal activities. In addition, the article presents a call for collective action to protect an endangered animal species.

Keywords: whale shark, extinction, anthropogenic impact, marine giants, ocean animals, ship collisions.

ВЛИЯНИЕ АНТРОПОГЕННОЙ ДЕЯТЕЛЬНОСТИ НА ВЫМИРАНИЕ КИТОВОЙ АКУЛЫ (*RHINCODON TYPUS*)

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Аннотация. Антропогенное воздействие приводит к сокращению численности китовой акулы (*Rhincodon typus*), самой крупной рыбы в мире и вида, находящегося под угрозой исчезновения по версии МСОП, численность которого за 75 лет сократилась более чем на 50%.

В данной статье рассматривается антропогенное воздействие, в том числе аварии на судах (92% мест обитания акул пересекаются с судоходными путями), прилов рыбы, загрязнение океана (микропластик, тяжелые металлы), неэтичный туризм и браконьерство, а также приводятся данные о намеренном занижении смертности морских обитателей. В данном исследовании представлены практические решения для борьбы с антропогенными угрозами китовым акулам (*Rhincodon typus*), включая введение ограничений скорости и изменение маршрутов движения судов, ограничения на неэкологичные туристические круизы. В данной статье подчеркивается необходимость личной ответственность граждан, которая способствует предотвращению неэтичного туризма (например, кормление акул, суп из акульих плавников), чтобы предотвратить содержание незаконной деятельности. Кроме того, в статье представлен призыв к коллективным действиям по защите исчезающего вида животных.

Ключевые слова: китовая акула, вымирание, антропогенное влияние, морские гиганты, животные океана, столкновения с судами.

Anthropogenic impact on the world's oceans is increasing rapidly. Human populations keep growing from day to day so the anthropogenic activities on marine animals only widen. Human cause a lot of problems for all marine species, in particular, to whale sharks.

The whale shark (*Rhincodon typus*) is a marine giant and the world's largest extant fish. Whale sharks are classified as endangered on the IUCN Red List of Threatened Species, having seen its global population decline by more than 50% over the last 75 years. As filter feeders, whale sharks need to spend the most of their time swimming just below ocean surface. But because of their size, they are very slow and hulking, usually swimming with about 5 km/h. And that is why they are so vulnerable [3].

Almost two-thirds of the Indonesian whale shark population found off West Papua carry injuries from preventable human causes, a new international study has found. The current trajectory of the whale shark extinction is being shaped directly by human actions - from targeted fishing and bycatch to ship strikes and habitat degradation caused by marine debris and coastal development [1, 2].

Further, it should be noted that the human impact on the extinction of whale sharks includes several factors.

Ship collisions

There was a very popular opinion on whale shark extinction until recent time. A lot of people thought that the main cause of their declining number of species is commercial catch. Despite the protection of sharks in many countries in the 1990-2000s, their amount only grew smaller within each year.

In new studies it turned out that there was a more significant problem of whale shark extinction. It is ship collisions, also known as ships strikes. Nowadays about 80% of trading is carried by the sea, the ships travelling across the ocean take fixed shipping routes (marine highways). These marine highways often cross the movements and migratory routs of marine animals. Because of whale sharks' low speed, they don't have enough time to dodge and move out of ship routes.

In the new research they put electronics tags on almost 350 sharks to map their locations. They then compared their paths with mandatory ship tracking system that

was created to prevent ship collisions. It turned out that a staggering 92% of the horizontal space occupied by whale sharks and nearly 50% of their depth layers overlapped with the activities of these fleets. Then they created a model of areas, where the most of these routes go, and overlapped this with common areas of inhabitation of whale sharks [1, 3]. They found that the Gulf of Mexico, Arabian Gulf and Red Sea showed the highest risk to sharks. These regions have some of the world's busiest ports and sea passages, and because estimated levels of risk correlated with known fatal collisions here, they appear to be some of the most dangerous places in the world for whale sharks to inhabit.

Moreover, the speed of the vessels is about ten times faster than average speed of the shark, so animals have a very little time to respond to this threat. The researchers emphasize that whale shark tag transmissions ended more often in busy shipping lanes than they expected. And even after accounting random technical failures, still 24% of tags stopped transmitting due to the sharks' death after being struck by the ships. Some of the tags even detected depth as well as location and showed sharks moving into shipping lanes but then sinking slowly to the seafloor hundreds of metres below – the smoking gun for a lethal ship strike.

However, mortality cases from ship-strike most likely under-reported, as whale sharks don't float up and therefore sink and remain undetected if a collision is fatal.

Entanglement in fishery nets

Historically, whale sharks were the target of large-scale, commercial fisheries in India, China, Taiwan, and the Philippines, until the species was protected in these countries in the 1990–2000s. Despite the protection in many countries, harvesting of whale sharks has continued. In the areas, where whale sharks are relatively common (Maldives, Ningaloo Reef (Australia), Mexico's Yucatan Peninsula, the Philippines, Mozambique, and the Galapagos Islands), they are sometimes caught by fishermen. For example, to catch tuna it's commonly used a purse-seine net but unintentionally encircling sharks, foraging in the same areas. About 73% in the Western Central Pacific of whale sharks became entangled in purse-seine nets and were found only after nets being deployed. So banning commercial fisheries didn't help to avoid all the catches of sharks.

The same situation is happening in the Indian Ocean, tuna fishing using gillnets caused a huge bycatch of cetaceans, whale sharks in particular [6].

More sustainable and selective method of fishing is pole and line fishing. Which is basically placing barbless hooks in the water, scattering small live baitfish (such as sardines or anchovies) and causing tuna to bite at these hooks. So it is aiming only tuna and do not harm the sharks in any possible way. Thus, we should switch more on such kind of fishery methods to avoid bycatch of other species that mustn't be harvested [8].

Ocean pollution by chemicals and plastic

Whale sharks by cause of filter-feeding can swallow and then filtrate huge amounts of water. But because of anthropogenic impact on oceans, there might be a lot of pollutants in the liquid that they consume. It can be both chemical, such as toxic

trace elements, polychlorinated biphenyls (PCBs), pesticides and ganochlorines, and plastic. Heavy metals such as lead (Pb) and mercury (Hg) that are also swallowed with contaminated zooplankton and fish eggs. Furthermore, the physical ingestion of microplastics not only causes intestinal blockages. Consequently, juveniles in polluted aggregation sites, such as Indonesia and the Philippines, exhibit slower growth rates and higher stress hormone levels than those in remote, pristine waters.

In addition, oil spills and gas extractions affect marine ecosystems through toxic compounds. So, considering that whale sharks usually can be found in both coastal and oceanic habitats, they have very high risks on consuming these contaminants.

All this can affect sharks' health: nutrient absorption, reproductive system and other physiological problems that might lead to death of species.

Stress from unethical tourism

There are a lot of tours organized around the world to sea marine creatures. Often it includes watching whale sharks underwater and swimming near them or with them. But sometimes basic rules of ethical tourism are not taken in charge. So, people might swim up to the species too close, get on their way or even feed and touch them, which is completely not normal.

There is a common rule among biologists – the further you are from wild species, the better it is for them. Because we don't want to interrupt their life, change their behavior or even make them used to humans. All that can affect creatures very much, which can lead to unpredictable consequences [5].

Thus, approaching whale sharks is not a good idea at all, as well as touching and feeding them. By touching we can either transmit diseases from us to sharks or get them from animals. There are a lot of different bacteria that we can get from them and some of them might be very harmful. In the same way, we can damage the mucus layer covering whale sharks and release bacteria and parasites. Moreover, feeding wild animals is a very inappropriate thing to do because it breaks there natural breeding and foraging patterns, so they can't live on their own after getting used to all of that. Also, usually sharks get a lot of injuries from the boats and propellers in the areas, where they are usually fed.

Poaching activity

There is still a major threat to the whale sharks even though there are protecting laws on them. There were found different places around the world, where sharks were still slaughtered for sale. For example, there was found a huge whale shark slaughterhouse in southern China, where hundreds of them were killed annually for illegal trade. These places have become epicenters where these giants are butchered primarily for their valuable fins, which can fetch thousands of dollars per kilogram for shark fin soup, as well as for their meat and liver oil. And there are still more of them [7].

Finally, in December 2025 was organized the 20th Conference of the Parties (CoP20) to the Convention on International Trade in Endangered Species (CITES) in Samarkand, Uzbekistan, member countries voted to uplist the whale shark to Appendix

I – the highest level of protection under the convention [4]. That decision sent a clear sign that global community is not willing to tolerate the commercial exploitation of this endangered species.

Further, it should be noted that there are solutions to the problem of whale shark extinction and methods of combating it. We are gradually moving towards solving all these problems, but for now we still have a lot to do. For ship strikes people already offered an idea of speed limitations and moving shipping routes out of the sharks' natural habitats. But these are only recommendations targeted on whale shark protection. However, these limits are not enforced or monitored.

Nevertheless, we can put into practice limitations on passenger and tourist vessels. It's not necessary to travel this way and still that might help keep whale shark constellations safe. In addition, sometimes such kinds of cruise tourism can provide an ability to feed or swim with sharks, which was discussed previously as a very harmful thing to do. So, by these limitations we can both prevent ship collisions and unethical tourism.

At the same time, we can attract people to help tracking whale sharks and keep an eye on their population. Still, it must be some harmless ways, such as, tagging species, taking photos to identify each of them, which biologists commonly use to recognize a specific animal, creating maps of migrations and more other scientific methods.

Finally, the most important thing to do is not to support any kinds of unethical tourism by not only avoiding swimming in whale sharks' habitats and feeding them but also by not going for popular tourists' activities. Such as trying shark fin soups or other exotic meals that are often cooked illegally. Basically, it is about not sponsoring prohibited activities even though it might be interesting and fun. We need to remember that not everything that seems cool and not that important for us, still the same safe and healthy for marine animals, especially to the ones who are endangered.

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УДК 574

WHALE-FALL ECOSYSTEMS DYNAMICS AND PATTERNS

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Abstract. This study reviews and synthesizes existing literature on whale-fall ecosystems, with particular focus on decomposition processes and associated biological communities. Whale falls represent deep-sea habitats that develop through a sequence of ecological stages, including scavenger, enrichment-opportunist, sulphophilic, and reef phases. Due to the rarity of natural whale falls, current understanding is based largely on documented case studies and experimental simulations using artificial carcasses. The analysis compares published studies, including deep-sea experiments with cow carcasses deployed at different depths, to identify general patterns in ecosystem succession. Results indicate that water depth strongly affects decomposition rates and community structure, with shallower sites showing faster scavenger activity and deeper environments supporting slower and less diverse assemblages. Overall, whale-fall ecosystems are important for deep-sea biodiversity and carbon cycling, but remain insufficiently studied.

Keywords: whale fall, carcass decomposition, deep-sea ecosystems, sea floor, ecological succession

ДИНАМИКА И ЗАКОНОМЕРНОСТИ ЭКОСИСТЕМ КИТОПАДОВ

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Аннотация. Данное исследование представляет собой обзор и синтез существующей научной литературы о экосистемах китопадов, с особым вниманием к влиянию глубины воды на процессы разложения и связанные с ними биологические сообщества. Экосистемы китопадов формируются в ходе последовательных экологических стадий, включая стадии падальщиков, обогащения органическим веществом, сульфофильную и рифовую стадии. В

связи с редкостью наблюдения естественных китопадов современные знания основаны преимущественно на описанных случаях и экспериментальных моделях с использованием искусственных туш. В работе сопоставляются опубликованные исследования, включая эксперименты с использованием туш крупного рогатого скота, размещённых на различных глубинах, с целью выявления общих закономерностей сукцессии экосистем. Результаты показывают, что глубина воды существенно влияет на скорость разложения и структуру сообществ: на меньших глубинах наблюдается более высокая активность падальщиков, тогда как на больших глубинах процессы протекают медленнее и сопровождаются меньшим биоразнообразием. В целом экосистемы китопадов играют важную роль в биоразнообразии глубоководной среды и круговороте углерода, однако остаются недостаточно изученными.

Ключевые слова: китопад, разложение туш, глубоководные экосистемы, морское дно, экологическая сукцессия

Introduction

A whale fall is a natural phenomenon that occurs when the carcass of a whale sinks to the ocean floor and becomes a concentrated source of nutrients for deep-sea organisms. Over time, it gives rise to a distinct ecosystem that can persist for 50-75 years. These ecosystems develop through a series of ecological stages, each characterized by different biological communities [2, 5].

These ecosystems are important for deep-sea biodiversity and carbon cycling. However, as natural whale falls are rare and difficult to observe directly, scientific understanding is largely based on documented case studies and experimental simulations reported in literature [2, 5].

Aim of the research

The aim of this study is to review and synthesize existing literature on whale-fall ecosystems, with particular attention to the role of water depth in influencing decomposition rates. The study also compares published experimental case studies using artificial carcasses to identify general patterns in whale-fall succession.

Materials and methods

This study is based on a narrative review of scientific literature on whale-fall ecology, including published observational and experimental studies. Sources describing natural whale falls and deep-sea simulation experiments were analyzed and compared.

In particular, reported experiments using artificial carcasses (e.g. cow carcasses deployed at different depths in the South China Sea) were used as comparative case studies [7]. These studies employed underwater cameras and oceanographic instruments to monitor decomposition processes and scavenger communities.

The collected information as synthesized in order to identify common patterns in decomposition dynamics and ecological succession across different depths.

Results and discussion

The reviewed literature shows that whale-fall ecosystems develop through a sequence of ecological stages, including mobile scavenger, enrichment-opportunist, sulphophilic, and reef stages, each characterized by specific biological communities and decomposition processes (Figure 1) [3, 6].

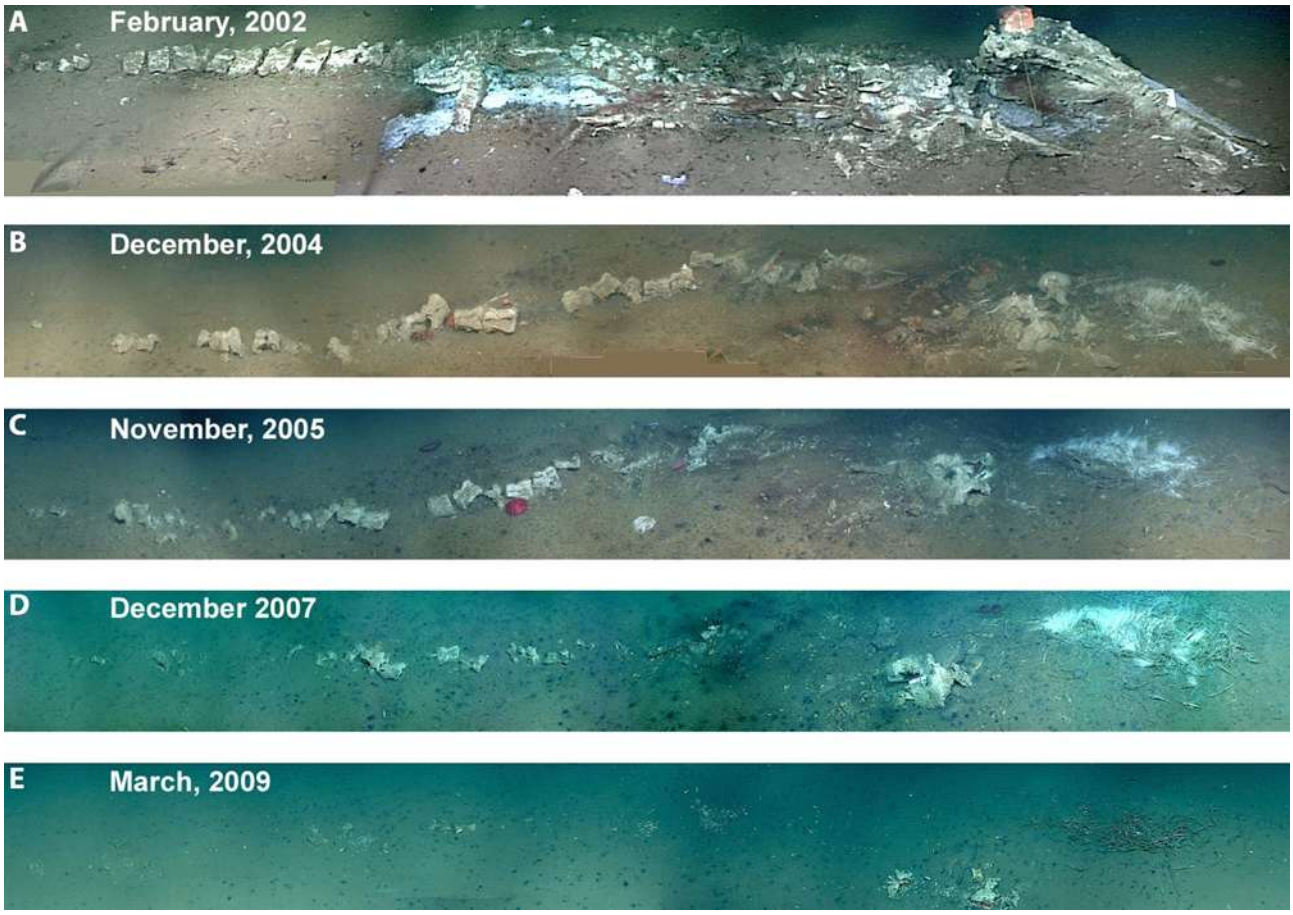

Figure 1. A photomontage showing the decomposition of a 3,000-meter-deep whale carcass in Monterey Canyon over a seven-year period. © 2010 MBARI

The first stage is the mobile-scavenger stage, during which large scavengers such as hagfish, sleeper sharks, rat-tails (also known as grenadiers), molluscs, and crustaceans (e.g., tanner crabs and isopods) initiate the rapid consumption of the soft tissues of the carcass (40-60 kg / day). This stage may last from several months to one and half years.

It is followed by the enrichment-opportunist stage, in which smaller deep-sea scavengers (crustaceans and molluscs in particular) from the previous stage burrow into the sediment in search for remaining soft organic material.

Subsequently, bones are also involved in the food chain, becoming a key resource in the ecosystem. The main extractors of lipids and proteins from osseous tissue are specialized organisms such as *Osedax* (sometimes called zombie, snot, or bone-eating worms) – a genus of segmented worms (Figure 2) – which secrete acids to facilitate the absorption of nutrients for the bones [2]. This stage may last from several months to four and half years.

Figure 2. Vertebrae from a whale about seven months after its carcass fell the bottom of the Pacific Ocean covered with a dense carpet of red *Osedax* 'bone-eating' worms. © 2006 MBARI

Later, sulphophilic communities develop: in this stage, the whale fall is inhabited by sulphur-oxidising bacteria and chemosynthetic organisms such as clams that release hydrogen sulphide as a waste product, which is then metabolised by chemoautotrophic bacteria. Generally lasting for about 50 years, this stage may be slowed down to 100 years due to a combination of environmental factors.

Finally, the reef stage is reached, during which the whale fall runs out of most nutrients and the site is colonized by populations of sponges, tunicates, and bivalves.

As mentioned before, whale falls are a rare sighting. For this reason, scientists use stranded cetaceans as model objects that are artificially sunken and observed. Such experimental studies play a key role in the discovery of new marine species and in the research of naturally occurring carbon sequestration in the ocean [4, 6].

Due to the fact that chances of stumbling upon a natural whale fall are quite low and carcasses of stranded cetaceans are limited, cadavers of cattle are also used for simulations.

One experimental study reported in the literature [7] deployed three cow carcasses (approximately 600 kg each) at depths of 650 m, 1,600 m, and 3,400 m on the Zhongnan seamount in March 2021 (Figure 3). The experiment was carried out to test the hypothesis that water depth has an impact on whale fall ecosystems. The decomposition process was monitored using cameras and oceanographic instruments installed on a remotely operated system (HOV *Shenhaiyongshi*).

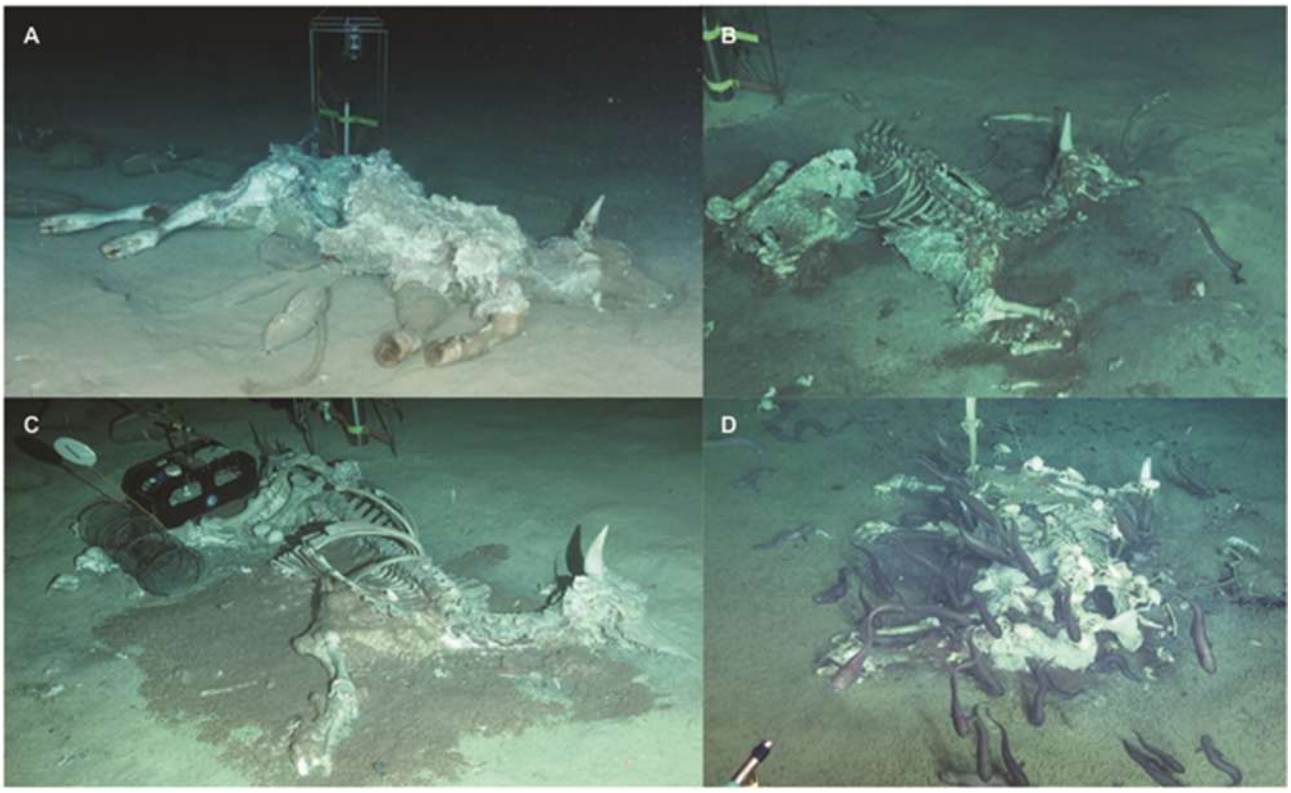

Figure 3. The images of the 3 dead cow carcasses on the slopes of the Zhongnan seamount at 650 m (A-B), 1,600 m (C), and 3,400 m (D).

At 650 m, approximately half of the soft tissues was consumed within 24 h (Fig. 3A), and complete decomposition occurred within a short period (Fig. 3B). At 1,600 m, decomposition was slower but still efficient, with most soft tissues consumed over time (Fig. 3C). At 3,400 m, the carcass decomposed much more slowly and remained partially intact, having still some flesh attached to the bones and showing a lower diversity of surrounding organisms, primarily fish, over a comparable period of time (Fig. 3D). These observations suggest a strong influence of water depth on the consumption rate and on the biodiversity of communities found on whale falls.

However, the significantly larger size of whale carcasses is responsible for the “seamount effects” which cannot be fully replicated using bovine models. Moreover, simulated studies have revealed species that had not been previously reported in the South China Sea. This highlights both the ecological importance of whale falls and the current limitations in deep-sea biodiversity research. [7]

Marine biology is still in an early stage of exploration in this field, as many whale-fall-associated species remain unknown. More than half of known whale-fall specialists have been reported from the California margin, indicating that global diversity is still underestimated [5].

Conclusions

Whale-fall ecosystems represent important deep-sea habitats that develop through a predictable sequence of ecological stages and contribute significantly to marine biodiversity and nutrient cycling. The reviewed literature demonstrates that water depth is a key factor influencing decomposition rates and community structure,

with shallower environments supporting faster and more diverse scavenger activity, while deeper environments exhibit slower and more specialized ecological processes.

Artificial carcass experiments provide useful models for studying whale-fall dynamics, although they cannot fully replicate the scale and complexity of natural whale falls. Despite significant progress, whale-fall ecosystems remain insufficiently studied, and many associated species are still unknown. Further research is therefore essential to improve understanding of deep-sea ecological processes and biodiversity patterns.

Overall, whale-fall ecosystems should be considered not only as biological phenomena but also within the broader context of sustainability and green economy [1, 3], as they are linked to carbon sequestration and deep-sea ecosystem functioning. Understanding these processes may contribute to more informed approaches to marine conservation and sustainable management of ocean resources. At the same time, significant gaps remain in knowledge, and many species associated with whale-fall environments are still undiscovered.

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PERSONAL EXPERIENCE IN BREEDING THE GIANT FRESHWATER PRAWN *MACROBRACHIUM ROSENBERGII* (de Man, 1879)

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Abstract: The paper presents the biological characteristics and breeding technologies of the giant freshwater prawn *Macrobrachium rosenbergii* (de Man, 1879). Based on his own practical experience, the author examines the key aspects of keeping this species under recirculating aquaculture system (RAS) conditions. Conclusions are drawn regarding the potential of *M. rosenbergii* as an aquaculture species, and the main challenges encountered in its breeding are outlined.

Keywords: shrimp, *Macrobrachium rosenbergii*, aquaculture, freshwater prawns, breeding, recirculating aquaculture system (RAS), giant freshwater prawn

ЛИЧНЫЙ ОПЫТ РАЗВЕДЕНИЯ ГИГАНТСКОЙ ПРЕСНОВОДНОЙ КРЕВЕТКИ *MACROBRACHIUM ROSENBERGII* (de Man, 1879)

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Аннотация: В статье представлены биологические особенности и технологии разведения гигантской пресноводной креветки *Macrobrachium rosenbergii* (de Man, 1879). На основе собственного практического опыта авторы рассмотрели ключевые аспекты содержания данного вида в условиях замкнутого цикла. Сделаны выводы о перспективности *M. rosenbergii*, как объекта аквакультуры и обозначены основные трудности, возникающие при её выращивании.

Ключевые слова: креветки, *Macrobrachium rosenbergii*, аквакультура, пресноводные креветки, разведение, установка замкнутого водоснабжения (УЗВ), гигантская креветка

Introduction

Shrimp represent a vast group of decapod crustaceans, numbering more than 2,000 species. About 35 species are harvested and cultivated on an industrial scale, with marine warm-water shrimp *Penaeus vannamei* and *Penaeus monodon* occupying leading positions. However, freshwater species, in particular the giant freshwater prawn *Macrobrachium rosenbergii*, possess significant potential for aquaculture development in regions remote from the sea coast [1-3].

Global shrimp production is based on several key groups: marine warm-water shrimp (family *Penaeidae*), freshwater shrimp (genus *Macrobrachium*), cold-water wild-caught species (genus *Pandalus*), and ornamental shrimp (genera *Caridina* and *Neocaridina*). Marine warm-water shrimp account for more than 80% of global aquaculture production. The whiteleg shrimp *P. vannamei* is the undisputed leader due to its rapid growth and tolerance to varying salinity [4]. The tiger shrimp *P. monodon* reaches larger sizes (up to 250 g) but is more demanding in terms of water quality [5].

Freshwater shrimp of the genus *Macrobrachium* (over 240 species) inhabit rivers and lakes but require brackish water for larval development. The giant freshwater prawn *M. rosenbergii* is the largest representative, with males reaching 30–32 cm and weighing up to 300 g [2, 3].

Cold-water shrimp (e.g., *Pandalus borealis*) are primarily harvested through wild capture and are valued for their sweet meat. Ornamental shrimp (e.g., *Neocaridina davidi*) are bred for aquariums and have numerous color variations [4].

Research aim and objectives

The aim of the paper is to present an overview of the main cultivated shrimp species and to summarize personal practical experience in breeding the giant freshwater prawn *Macrobrachium rosenbergii* under closed-loop recirculating aquaculture system (RAS) conditions.

Objectives:

1. to describe the main groups of cultivated shrimps (marine warm-water, freshwater, cold-water wild, and ornamental species) based on literature data;
2. to characterize the biological features, life cycle, and reproductive biology of *Macrobrachium rosenbergii*;
3. to share the author's own practical experience in rearing *M. rosenbergii* in RAS, including feeding, temperature management, and cannibalism prevention;
4. to identify the main challenges and prospects for cultivating *M. rosenbergii* in regions remote from the sea coast, including Russia;
5. to formulate practical recommendations for maintaining and growing *M. rosenbergii* under artificial conditions.

Materials and methods

The study was based on two complementary approaches: a review of scientific literature on shrimp taxonomy, biology, and aquaculture, and the author's own

practical experience in rearing *Macrobrachium rosenbergii* under controlled conditions.

Scientific publications on cultivated shrimp species, their systematic position, biological characteristics, and aquaculture technologies were analyzed. The review covered Russian and international sources, including monographs [2–5] and recent articles on the cultivation and artificial reproduction of *Macrobrachium rosenbergii* [6–8].

The author conducted rearing of *Macrobrachium rosenbergii* over several months in a recirculating aquaculture system (RAS). The equipment included tanks and aquariums with a total water volume of 1,986 liters and 200 liters. The RAS was equipped with a heater, an aeration system, and a mechanical and biological water filtration unit (Figures 1 and 2).

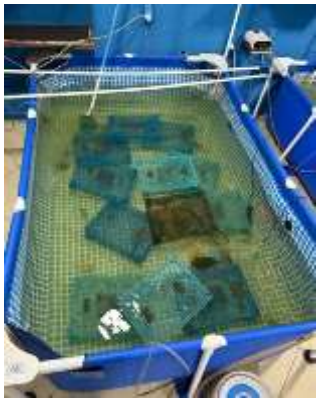

Figure 1. Tank for prawn grow-out (author's photo).

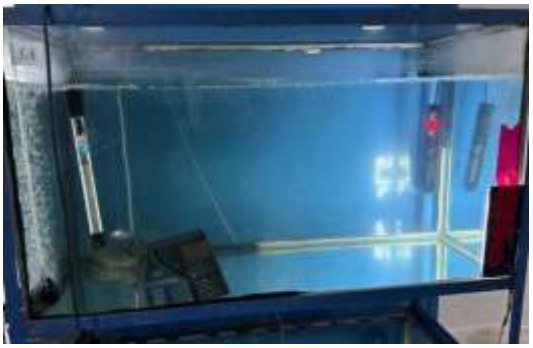

Figure 2. RAS for prawn cultivation (author's photo).

Water temperature was maintained at 27–29°C, as this range is optimal for the growth and development of the species. When the temperature dropped to 24°C or below, the author observed a noticeable decrease in locomotor activity and appetite. Salinity for larval development was maintained at 7,700–8,000 ppm (7.7–8.0‰).

The prawns were fed once daily using a specialized formulated feed (Figure 3).

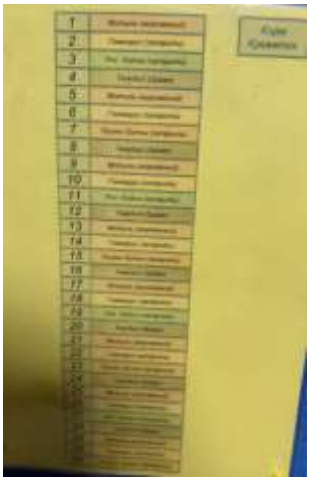

Figure 3. Prawn feeding schedule (author's photo).

The author noted that the prawns readily consumed both animal-based and plant-based feeds, confirming their omnivorous nature.

To reduce cannibalism – a characteristic problem of this species under artificial rearing conditions – numerous shelters (hiding places made of tubes, stones, and artificial refuges) were placed in the aquariums and tanks.

The author regularly monitored the following parameters: growth rate, locomotor activity, appetite, molting frequency, and mortality. Photographs were taken throughout the rearing period to document key stages and conditions. These included: a female with eggs (Figure 4), a giant freshwater prawn raised on the author's farm (Figure 5), and prawns at 7 months of age (Figure 6).

Figure 4. Female with eggs (author's photo).

Figure 5. Giant freshwater prawn *Macrobrachium rosenbergii* raised on the author's farm (author's photo).

Figure 6. Giant freshwater prawn *Macrobrachium rosenbergii* at the age of 7 months (author's photo).

The obtained empirical observations were compared with literature data to confirm or clarify existing knowledge on the biology and rearing requirements of *Macrobrachium rosenbergii*.

Research results

Overview of cultivated shrimp groups:

– Marine warm-water shrimp: *P. vannamei* (20–23 cm, 30–45 g) and *P. monodon* (up to 30 cm, 250 g) dominate global aquaculture.

- Freshwater shrimp: *M. rosenbergii* (males up to 32 cm, 300 g) is the most commercially significant freshwater species.
- Cold-water shrimp: *Pandalus borealis* (up to 12 cm) is harvested wild in the North Atlantic and North Pacific.
- Ornamental shrimp: *Neocaridina davidi* (2.5–4 cm) is the most popular aquarium species [2–5].

Biological characteristics of *Macrobrachium rosenbergii*:

- Males have three morphotypes: Blue Claw (dominant), Orange Claw (subdominant), and Small Male (subordinate) [2].
- Sexual maturity occurs at 3–5 months. Fecundity ranges from 10,000 to 50,000 eggs per spawning.
- Larval development requires brackish water (7.7–8.0‰) and lasts 25–35 days at 28–30°C.
- Postlarvae (7–10 mm) then migrate to fresh water [3, 6].

The author documented the rearing process with personal photographs. Figure 6 shows *Macrobrachium rosenbergii* at the age of 7 months. Figure 5 shows a giant freshwater prawn raised on the author's farm. Figure 4 shows a female carrying eggs on her pleopods. Figures 1 and 2 show the tank for prawn grow-out and the RAS system used. Figure 3 shows the prawn feeding schedule.

Optimal growth was observed at 27–29°C. At 24°C and below, locomotor activity and appetite decreased significantly. The prawns readily consumed both animal- and plant-based feeds, confirming their omnivorous nature [7].

To reduce aggression and mortality (especially among molting individuals with soft carapaces), numerous shelters were placed. This measure significantly reduced mortality. The author successfully maintained and reared *M. rosenbergii* in RAS conditions, confirming literature data on the species' requirements [6, 7].

Main challenges identified:

- Requirement for brackish water for larval development.
- Tendency toward cannibalism at high stocking densities.
- Uneven growth rates requiring regular grading of the stock [2, 3].

Conclusion

Based on the review of literature data and the author's own practical experience, the following conclusions can be drawn:

1. The global diversity of cultivated shrimp is represented by three main groups: marine warm-water shrimp (dominated by *Penaeus vannamei*), freshwater shrimp (genus *Macrobrachium*), and cold-water wild-caught species (genus *Pandalus*). Each group occupies its own niche in global seafood production [2–5].

2. The giant freshwater prawn *Macrobrachium rosenbergii* is the largest and most commercially significant representative of freshwater prawns. Its biological characteristics – large size, omnivorous feeding habits, and rapid growth – make this species a promising object for aquaculture [2, 3].

3. The main challenges in cultivating *M. rosenbergii* are the requirement for brackish water for larval development and the tendency toward cannibalism at high stocking densities [6, 7].

4. The author's practical experience confirms the feasibility of successfully maintaining and growing *Macrobrachium rosenbergii* in recirculating aquaculture systems under optimal parameters: temperature of 27–29°C and the presence of shelters to reduce aggression.

5. *Macrobrachium rosenbergii* is of considerable interest for the further development of freshwater aquaculture in regions remote from the sea coast, including the territory of Russia.

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DISCHARGE OF POLLUTED WASTEWATER INTO SURFACE WATER BODIES

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Abstract: The article analyzes regional patterns of polluted water discharge into surface water bodies in Russia using Rosstat data for 2005 and 2010. The aim is to identify regions with the highest and lowest discharge levels, determine key factors, and assess overall trends. The analysis shows that regions with low discharge levels are typically characterized by geographical remoteness, harsh climatic conditions, low population density, and limited industrial activity. In contrast, high-discharge regions, including major urban and industrial centers such as Moscow and St. Petersburg, are associated with dense populations and developed industrial sectors. The findings highlight a strong link between wastewater discharge, industrialization, and urbanization, emphasizing the need for improved environmental policies and infrastructure.

Keywords: wastewater discharge, water pollution, regional analysis, industrialization

СБРОС ЗАГРЯЗНЕННЫХ СТОЧНЫХ ВОД В ПОВЕРХНОСТНЫЕ ВОДОЕМЫ

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Аннотация: В статье проанализированы региональные данные Росстата на 2005 и 2010 гг. о сбросе загрязненных сточных вод в поверхностные водоемы в России. Цель исследования – выделить регионы с наиболее высокими и низкими показателями по сбросу сточных вод, идентифицировать ключевые факторы и общие тенденции. В результате исследования выявлено, что регионы с наименьшими показателями характеризуются, как правило, географической отдаленностью, суровыми климатическими условиями, низкой плотностью

населения, ограниченным развитием промышленности. С другой стороны, регионы с высоким уровнем сброса включают крупные городские и промышленные центры, такие как Москва и Санкт-Петербург, для которых характерны плотное население и развитие промышленного сектора. Результаты исследования показали взаимосвязь между сбросом сточных вод, индустриализацией и урбанизацией, а также необходимость в улучшении политики защиты окружающей среды и инфраструктуры.

Ключевые слова: сброс сточных вод, загрязнение воды, региональные анализ, индустриализация

Introduction

Wastewater discharge refers to the release of water that has been contaminated by human domestic, commercial, or industrial activities. Wastewater can be discharged into sewage systems, water bodies, or directly onto the land. However, this may have negative environmental consequences, and is therefore prohibited by environmental regulations [4-8].

Wastewater pollution can be classified into three types: organic, mineral, and biological. Organic pollution refers to the presence of plant and animal matter. Mineral contaminants include quartz sand, clay, alkalis, mineral acids and their salts, mineral oils, and other substances. Biological contaminants include various microorganisms, such as yeast and mold fungi, small algae, and bacteria, including pathogens responsible for such diseases as typhoid, paratyphoid, dysentery, and others [1, 7].

Aim of the research

This study analyzes climatic data from 2005 and 2010, to assess the state of water bodies across different regions of Russia. The aim of the study is to identify which regions of Russia have the highest and lowest levels of wastewater discharge, and to determine the reasons behind their performance. For this purpose, the following research tasks were set:

- analyzing relevant data collected by Rosstat in 2005 and 2010;
- identifying regions with the lowest and highest wastewater discharge levels for both periods under study;
- determining common key factors affecting regions with the highest and lowest indicators;
- identifying some general trends.

Materials and methods

The study is based on data provided by the Russian Federal State Statistics Service (Rosstat).

The methodology includes a review of scientific literature, statistical data processing, and ranking.

Research findings and discussion

According to data collected by Rosstat, the indicators for discharge of pollutant wastewater into surface water can be visualized as shown in Figure 1.

Fig. 1. Discharge of pollutant wastewater into surface water bodies according to Rosstat data (million cubic meters).

In 2005, six regions were included in the lowest category, as shown in Figure 2: the Chechen Republic (0 million m³), the Altai Republic (0.5 million m^3), the Nenets Autonomous District (1.2 million m^3), the Ingushetia Republic (1.6 million m^3), the Chukotka Autonomous District (4 million m^3), and the Tyva Republic (8 million m^3).

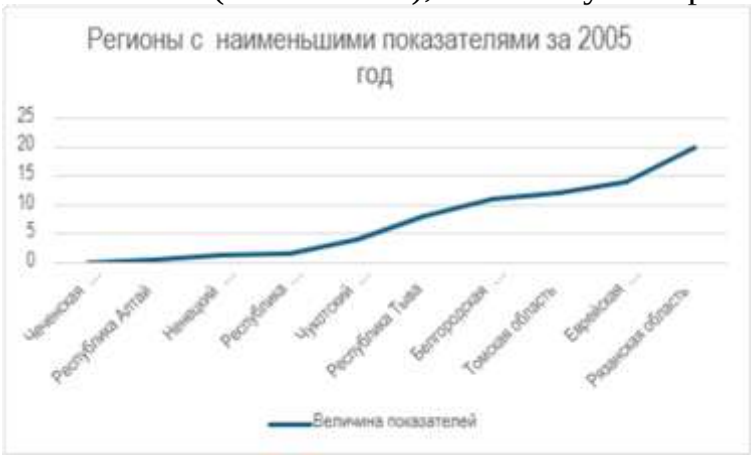

Fig. 2. Regions with lowest indicators for 2005.

In 2010, the composition of the group remained almost unchanged: the Chechen Republic (0 million m^3), the Nenets Autonomous District (0.3 million m^3), the Altai Republic (0.3 million m^3), the Ingushetia Republic (2.7 million m^3), the Chukotka Autonomous District (5 million m^3), and the Tyva Republic (9 million m^3).

These regions share several factors which may explain their consistently low levels of polluted wastewater discharge.

The first factor is geographical remoteness and harsh climatic conditions. Most of these regions (the Altai Republic, Tyva Republic, Chukotka Autonomous District, and Nenets Autonomous District) are located on the periphery of the country, in areas of permafrost or highlands. This location limits the scale of industrial development and population density. The harsh natural conditions make it difficult to build large industrial enterprises, which would otherwise be sources of pollution.

The second factor is low population density and small population size. With the exception of the Chechen Republic, all these regions are among the least populated in Russia. Small towns and villages generate insignificant amounts of municipal wastewater, which are often not included in official statistics as ‘polluted’ due to the lack of industrial components [2, 3].

The third factor is the lack of large-scale industry. These regions have almost no metallurgical, chemical, pulp and paper, or other industries, that typically generate significant wastewater pollution in industrialized regions. The local economy of these regions is based on agriculture, traditional crafts, small-scale mining, tourism, and the public sector.

As regards the regions with the highest discharge levels, in 2005, this group included Moscow (1,959 million m^3), St. Petersburg (1,188 million m^3), Sverdlovsk Region (814 million m^3), Irkutsk Region (814 million m^3), Krasnodar Territory (795 million m^3), Kemerovo Region (695 million m^3), Chelyabinsk Region (660 million m^3), Moscow Region (635 million m^3), the Republic of Tatarstan (529 million m^3), the Krasnoyarsk Territory (531 million m^3), as shown in Figure 3.

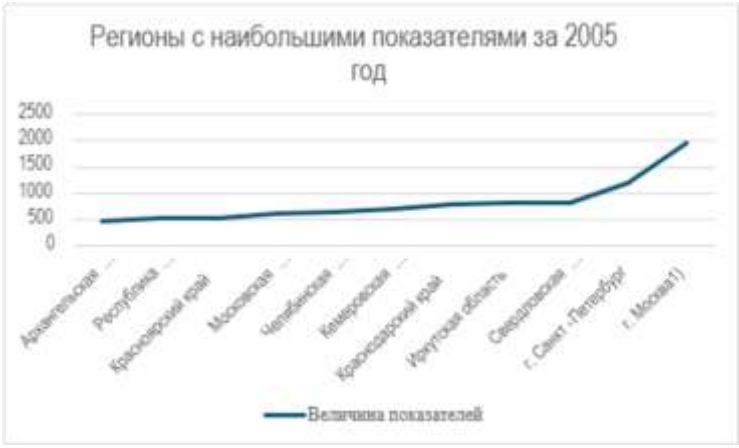

Fig. 3. Regions with highest indicators for 2005.

In 2010, the composition of this group shifted, with St. Petersburg (1,346 million m^3) and the Moscow Region showing the highest values (1,309 million m^3). They were followed by Moscow (909 million m^3), Krasnodar Territory (863 million m^3), Chelyabinsk Region (845 million m^3), Sverdlovsk Region (763 million m^3), Kemerovo Region (700 million m^3), Irkutsk Region (594 million m^3), Republic of Tatarstan (490 million m^3), and Krasnoyarsk Territory (444 million m^3), as shown in Figure 4.

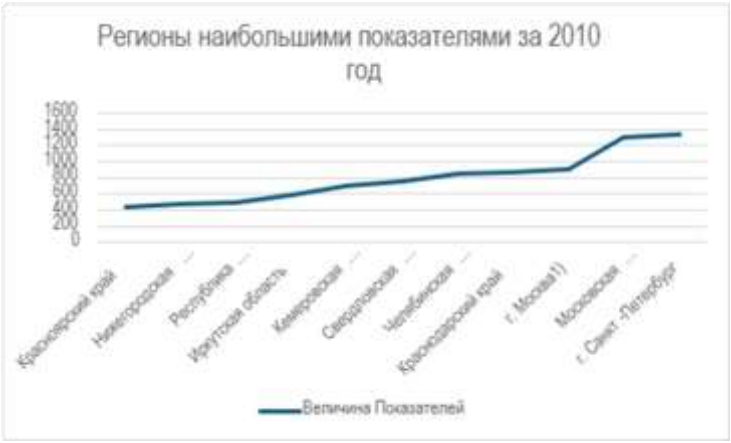

Fig. 4. Regions with highest indicators for 2010.

Moscow reduced its figures from 1,959 to 909 million m³ (less than half of the previous value) due to the mass relocation of industrial enterprises outside the city. However, this led to an increase in the figures for the Moscow Region from 635 to 1,309 million m³, which moved it to second place. St. Petersburg recorded an increase in its discharge from 1,188 to 1,346 million m³, reflecting its high concentration of industry (shipbuilding, mechanical engineering, and chemical industry) and dense urban development. The Krasnodar Territory showed an increase from 795 to 863 million m³ due to its developed agro-industrial sector (irrigation, agricultural processing, and livestock farming). The Sverdlovsk and Chelyabinsk Regions (industrial regions of the Urals with metallurgical and engineering enterprises) maintained high performance: the Sverdlovsk Region reduced its discharge from 814 to 763 million m³, while the Chelyabinsk Region increased its discharge from 660 to 845 million m³. These regions account for approximately 7% of Russia's annual industrial emissions. The Kemerovo Region (also known as Kuzbass) maintained a consistently high level (695 and 700 million m³) due to coal mining and metallurgy. The Irkutsk Region and the Krasnoyarsk Territory reduced their emissions (from 814 to 594 and from 531 to 444, respectively), but remained in the high-emission group due to aluminum factories, pulp and paper production, and hydropower. The Republic of Tatarstan reduced its figures from 529 to 490 million m³, moving to the third place, but retained the influence of the oil-producing and oil-refining industries.

Taking into account the overall dynamics across all regions, the total discharge of polluted wastewater in Russia declined between 2005 and 2010. This is due to the implementation of more efficient treatment technologies, the partial reorientation of industries, the tightening of environmental requirements, and the consequences of the 2008-2009 economic crisis, which led to a decline in production in certain sectors.

As regards the regions with low indicators, the composition of the group has remained almost unchanged (6 regions). Their indicators are consistently low (up to 9 million m^3) with a slight downward trend as regards the Altai Republic and the Nenets Autonomous District. As stated above, the main reasons for their performance include peripheral location, small population, lack of large-scale industry, and strict environmental control. None of the regions identified in 2005 has left or re-entered their rank category, which indicates stability within the group.

As far as the regions with high indicators are concerned, the situation is more complex. Moscow has significantly reduced its indicators owing to the relocation of production facilities to the Moscow Region, which, on the other hand, has sharply increased its discharge levels and entered the top 5. St. Petersburg, the Krasnodar Territory, and the Chelyabinsk Region have increased their indicators as a consequence of population, industrial, or agro-industrial growth. In contrast, the Sverdlovsk, Irkutsk, and Kemerovo Regions, as well as Tatarstan and the Krasnoyarsk Territory have shown a decrease, yet still remain in the group of regions with the highest indicators. In general, the combination of large cities, industrial clusters (metallurgy, chemistry,

petrochemicals, and energy production), and high population density are considered key factors for high indicators [9].

Conclusion

The analysis shows that in 2010 less wastewater discharge levels were generally lower than in 2005 across all Russian regions. More detailed analysis revealed that the largest cities in Russia have the highest wastewater discharge rates, particularly Moscow (2005: 1,959 million m^3; 2010: 909 million m^3), and St. Petersburg (2005: 1,188 million m^3; 2010: 1,346 million m^3, while the lowest levels are observed in sparsely populated regions such as the Chechen Republic with the lowest indicators (2005: 0 million m^3; 2010: 0 million m^3). Comparison between discharge data and geographical data indicate that regions with large cities or industrially developed centers show the highest indicators.

The rational use of water resources remains a critical environmental issue. This is primarily about protecting water bodies from pollution, and since industrial wastewater is the most significant in terms of volume and damage, it is crucial to address the issue of wastewater discharge into rivers and other water bodies. This includes limiting wastewater discharge and improving production, treatment, and disposal technologies. Additionally, it is important to implement fees for wastewater discharge and pollutant emissions, and use these funds to develop new waste-free technologies and treatment facilities. It is necessary to reduce the amount of environmental pollution fees for enterprises with minimal emissions and discharges, which will serve as a priority for maintaining or reducing the minimum discharge. A key priority is the development of a comprehensive regulatory framework to reduce water pollution in Russia.

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ECOLOGY, DISTRIBUTION AND CONSERVATION OF THE QUOKKA (*SETONIX BRACHYURUS*)

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Abstract: This article presents a review of current scientific knowledge on the biology, ecology, and conservation of the quokka (*Setonix brachyurus*), an endemic marsupial species of southwestern Australia. The study synthesizes published data on taxonomy, morphology, distribution, feeding ecology, and reproductive adaptations, with particular attention to embryonic diapause and water balance. Special emphasis is placed on the analysis of major threats, including introduced predators, wildfires, habitat loss, and genetic isolation. The review also examines current conservation strategies, such as predator control programs and long-term monitoring initiatives. The findings indicate that while insular populations remain relatively stable due to geographic isolation, mainland populations continue to decline. The study highlights the importance of integrated conservation measures and provides a comprehensive overview of factors influencing the long-term survival of the species.

Keywords: quokka, marsupial, conservation, habitat loss, predation

ЭКОЛОГИЯ, РАСПРОСТРАНЕНИЕ И ОХРАНА КВОККИ (*SETONIX BRACHYURUS*)

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Аннотация: В статье представлен обзор современных научных данных о биологии, экологии и охране квокки (*Setonix brachyurus*) — эндемичного сумчатого вида юго-западной Австралии. В работе обобщены опубликованные сведения о таксономии, морфологии, распространении, пищевой экологии и репродуктивных адаптациях, с особым вниманием к эмбриональной диапаузе и водному балансу. Особое внимание уделяется анализу основных угроз, включая интродуцированных хищников, лесные пожары, утрату местообитаний и генетическую изоляцию. Рассматриваются современные меры охраны, такие как программы контроля хищников и долгосрочный мониторинг популяций. Показано, что островные популяции остаются относительно стабильными благодаря изоляции, тогда как материковые популяции продолжают сокращаться. Подчеркивается необходимость комплексных мер охраны и даётся обобщённая характеристика факторов, влияющих на долгосрочное сохранение вида.

Ключевые слова: квокка, сумчатые, охрана природы, утрата места обитания, хищничество

Introduction

The quokka (*Setonix brachyurus*) is one of the most recognizable yet insufficiently studied marsupials of Australia. Due to its characteristic “smiling” facial expression, it is often informally referred to as “the world’s happiest animal.” The species is endemic to southwestern Australia and currently holds a Vulnerable (VU) status on the IUCN Red List, while also being protected under national Australian legislation [2].

Historically, quokkas were widely distributed across coastal areas from Perth to Albany, including forested regions and coastal shrublands. Nowadays, their range has significantly decreased due to habitat loss, introduced predators, and anthropogenic landscape transformation [3]. At present, stable populations remain mainly on Rottnest and Bald Islands, while mainland populations are small, fragmented, and declining.

This article reviews key aspects of quokka biology, including taxonomy, morphology, distribution, ecology, feeding behavior, water balance, major threats, and conservation strategies.

Aim of the research

The aim of this study is to synthesize current scientific knowledge on the biology, ecology, and conservation status of the quokka (*Setonix brachyurus*).

The research objectives include:

- analysis of taxonomy and morphological characteristics;
- description of historical and current distribution;
- identification of key ecological adaptations;
- evaluation of major threats to population stability;
- assessment of implemented conservation measures.

Materials and methods

This study is based on a narrative literature review. The analyzed materials include peer-reviewed scientific publications, ecological reports, and conservation program documentation related to *Setonix brachyurus*.

The methodological approach includes qualitative synthesis and comparative analysis of published data on morphology, distribution patterns, ecological adaptations, and conservation outcomes. Particular attention is given to studies on diet composition, reproductive biology, water balance, and population dynamics in island and mainland environments.

Results and Discussion

1. Taxonomy and Morphological Features

The quokka belongs to the family *Macropodidae*, which includes kangaroos and wallabies, characterized by a distinct mode of locomotion based on jumping.

Unlike most macropods, the quokka is classified in a separate genus, *Setonix*. The species name *Setonix brachyurus* derives from the Greek roots *brachys* (short) and *oura* (tail), meaning "short-tailed" and referring to its relatively reduced tail length.

Quokkas are relatively small marsupials with a body length of 40–54 cm, tail length of 25–30 cm, and body mass ranging from 2.5 to 5 kg. Sexual dimorphism is present, with males generally larger than females. Their fur is coarse, ranging from grey-brown to reddish tones. A common trait shared with other members of the *Macropodidae* family is the elongated form of the hind limbs; however, in addition to jumping, quokkas can also climb on low shrubs and rock formations, which is a rare ability within the family.

Another key difference from their close relatives is the absence of large forelimb claws, reflecting their terrestrial lifestyle.

Like other marsupials, one of the main and most interesting biological features of quokkas is embryonic diapause: after giving birth, embryonic development is temporarily suspended at the earliest phase of development until the pouch becomes available. This enables rapid population recovery under favorable conditions.

2. Distribution and Endemism

Historically, the quokka's range covered southwestern Australia, including the area between Perth and Albany, the woodlands of Jarrah Forest, the coastal shrubland, and several offshore islands, such as Rottnest, Bald, and Penguin Island [3].

Following European settlement, mainland populations declined sharply due to the introduction of predators such as the red fox (*Vulpes vulpes*) and feral cats, with which quokkas had no prior evolutionary exposure. In addition, land reclamation for agriculture and urban development led to extensive destruction of up to 80% of their natural habitat [3].

Currently, the largest quokka populations are found on Rottnest Island (approximately 8,000–12,000 individuals) and Bald Island (around 2,000 individuals) [2]. Population survival on the islands has been facilitated by the absence of foxes and

feral cats. On the mainland, only small, isolated populations remain in fragmented habitats.

Behavioral differences have also been observed: island populations are largely diurnal, whereas mainland populations are primarily nocturnal, likely as an adaptation to predation pressure [3].

3. Major Threats

The major threats to the conservation of quokkas include three main factors: predation, wildfires, and genetic isolation.

The primary threat on the mainland is predation by red foxes (*Vulpes vulpes*) and feral cats. Although predator control programs have been implemented, particularly targeting fox populations, mainland quokkas remain highly vulnerable: the situation is more stable than in the past, but still far from a full recovery of mainland populations [1].

Southwestern Australia is highly prone to wildfires. Large-scale fires in 2015 caused the loss of approximately 89,000 ha of woodland in the Jarrah Forest, resulting in the death of approximately 500 quokkas [5, 6]. Studies have shown post-fire reductions of up to 84% in affected areas, with recovery requiring more than five years. Controlled fires, however, may induce behavioral avoidance strategies, with quokkas relocating to refuge areas to survive unfavorable conditions [5, 7].

Insular populations have shown reduced genetic diversity due to isolation, increasing the risk of inbreeding and accumulation of recessive or undesirable alleles. The population of Bald Island is especially genetically homogenous, which leads to a decrease in disease and ecological resistance [3]. In contrast, mainland populations retain higher genetic diversity (up to 70%) but are fragmented and too small for long-term stability.

4. Feeding Ecology and Water Balance

Quokkas are obligate herbivores, feeding exclusively on plant material. A 2005 study based on fecal analysis identified 29 plant species in their diet, including *Thomasia*, *Dampiera hederacea*, *Bossiaea aquifolia*, and *Agonis linearifolia*. Their diet composition varies seasonally and is strongly influenced by vegetation succession following fire events, with higher nutritional value found in young regrowth stages [4].

Quokkas also demonstrate a unique physiological adaptation among marsupials: the ability to survive without direct access to drinking water during summer periods. Experimental studies have shown that individuals can maintain hydration through metabolic water and plant intake, although access to saline water may influence physiological stress responses [2].

5. Conservation Measures

The quokka is classified as Vulnerable (VU) by the International Union for Conservation of Nature (IUCN) and is protected under Australian national legislation.

Key conservation initiatives include the “Quokka Recovery Plan”, which aims to preserve quokka distribution and stabilize their populations over a 10-year period [2]. Within this framework, the Western Shield program focuses on predator control in

national parks using baiting strategies and habitat management [1]. The program includes recommendations for private landowners on how to preserve vegetations on their land plots and the request to keep domestic dogs and cats inside their houses or in open-air enclosures during nighttime. Additional monitoring programs on Rottnest and Bald Islands track population health through metrics such as body weight, weaning age, body condition, and relative population [2].

Conclusions

The quokka (*Setonix brachyurus*) is an endemic marsupial of southwestern Australia with unique morphological, ecological, and reproductive adaptations. Its current distribution reflects severe contraction following European colonization, with stable populations now largely restricted to predator-free islands such as Rottnest and Bald Island.

While isolation has helped prevent the extinction on this species in insular environments, mainland populations face ongoing threats from introduced predators, habitat loss, wildfires, and genetic isolation. Although conservation programs have improved population stability in protected areas, mainland populations remain highly vulnerable. Long-term survival of the species depends on continued predator control, habitat restoration, and systematic monitoring.

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HAOLONG DONGI: MORPHOLOGY, STRUCTURE OF KERATINOUS SPINES AND THEIR FUNCTIONAL SIGNIFICANCE

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Abstract: *Haolong dongi* is a recently described iguanodontian dinosaur from the Early Cretaceous Yixian Formation of China, notable for the exceptional preservation of its integumentary structures. The specimen exhibits a unique combination of three skin types, including previously unknown hollow keratinous spines covering most of the body. This study analyzes the morphology of these structures, evaluates their autapomorphic significance, and examines their possible functional roles, including defense, thermoregulation, sensory perception, and display. Comparative analysis with theropod protofeathers and reptilian integument suggests that these spines represent a novel type of dinosaurian skin appendage. The most strongly supported interpretation identifies a primarily defensive function. The discovery of *H. dongi* significantly expands current understanding of dinosaur integument diversity and evolutionary experimentation.

Keywords: *Haolong dongi*, *Iguanodontia*, keratinous spines, integumentary structures, functional morphology, autapomorphies

HAOLONG DONGI: МОРФОЛОГИЯ, СТРУКТУРА КЕРАТИНОВЫХ ШИПОВ И ИХ ФУНКЦИОНАЛЬНОЕ ЗНАЧЕНИЕ

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Аннотация: *Haolong dongi* — недавно описанный игуанодонтный динозавр раннего мела из формации Исянь (Китай), отличающийся исключительной сохранностью кожных покровов. Образец демонстрирует уникальное сочетание трёх типов кожных структур, включая ранее неизвестные полые кератиновые шипы, покрывающие большую часть тела. В работе анализируется морфология этих структур, их значение как аутапоморфий, а также возможные функциональные интерпретации: защитная, терморегуляционная, сенсорная и демонстрационная. Сравнение с протоперьями теропод и чешуйчатыми покровами современных рептилий показывает, что данные шипы представляют собой новый тип кожных образований динозавров. Наиболее обоснованной признана защитная функция. Открытие *H. dongi* существенно расширяет представления о разнообразии и эволюционных возможностях покровов динозавров.

Ключевые слова: *Haolong dongi*, игуанодонты, кератиновые шипы, кожные покровы, функциональная морфология, аутапоморфии

Introduction

Haolong dongi is a recently described ornithischian dinosaur belonging to the iguanodontian clade [1–3]. The fossil material represents a nearly complete articulated skeleton of a juvenile individual discovered in the layers of the Yxian Formation at Lamagou village in the Liaoning Province, China [1, 2].

While the skeletal morphology of *Haolong* is typical of ornithischian dinosaurs, the most significant aspect of this discovery is the exceptional preservation of soft tissues [4, 5]. In particular, three types of integumentary structures have been identified on the body of *H. dongi*, with one of them being hollow keratinous spines covering most of the body except for the tail [5].

The presence of hollow keratinous spines is unprecedented among non-avian dinosaurs and represents the most distinctive diagnostic feature of *H. dongi* [4, 5]. This discovery provides new insights into the diversity and evolution of dinosaur integument [6].

Aim of the research

The aim of this study is to analyze the morphological characteristics of *Haolong dongi* in order to evaluate the evolutionary significance of its integumentary structures, with particular emphasis on the hollow keratinous spines.

The objectives of the study are:

- to analyze the structure of the keratinous spines;
- to identify and characterize the autapomorphies of Haolong dongi;
- to examine possible functional interpretations of the spines;
- to systematize available data on skeletal and integumentary morphology.

Materials and methods

This study is based on a qualitative analysis of published paleontological data describing *Haolong dongi*, including morphological descriptions and high-resolution fossil evidence reported in recent literature.

The methodological approach includes comparative morphological analysis of skeletal and integumentary structures, as well as evaluation of functional hypotheses based on anatomical features such as spine orientation, distribution, and density.

Comparisons are made with integumentary structures observed in other dinosaur groups (e.g., theropod protofeathers) and modern reptiles in order to assess structural and functional similarities and differences.

Results and discussion

1. Morphological features and autapomorphies of Haolong dongi

Haolong dongi was a relatively small hadrosauroid dinosaur. The preserved skeleton measures approximately 2.45 m in length. Based on the absence of vertebral fusion, researchers assume the specimen to have died at a young age, suggesting that adults may have reached lengths of 3 to 5.5 m. The estimated body mass is approximately 150 kg [5].

The skeletal morphology displays characteristics typical of basal hadrosauroids, including a relatively lightweight body structure, the ability for both bipedal and quadrupedal locomotion (based on the limb structure), and leaf-shaped teeth adapted for processing tough plant material [5].

The most remarkable feature, however, is the preservation of three distinct types of integumentary structures on the body of *H. dongi*:

- shield-like spines along the tail;
- tuberculate spines on the neck and thorax;
- hollow keratinous spines covering most of the body except the tail.

Prior to this discovery, information about the body coverings of basal iguanodontian dinosaurs was scarce and mainly consisted of isolated fragments of scale impressions [4, 5].

The combination of these features represents a unique set of autapomorphies. In particular, the presence of hollow keratinous spines covering the body is unprecedented among non-avian dinosaurs. Furthermore, the coexistence of three different integumentary types within a single specimen constitutes a derived feature not previously reported in iguanodontians [4, 5].

2. Structure of keratinous spines

The most distinctive feature of *Haolong dongi* is the presence of numerous integumentary spines growing among the scales and covering a significant area of the body [4, 5]. They are distributed mainly across the neck, back, and flanks. These structures are oriented parallel to each other, with their tips directed backwards.

The spines vary in size: most measure 2-3 mm in length, while medium-sized ones reach 5-7 mm, and the largest ones exceed 44 mm [5]. They are hollow,

cylindrical structures composed of keratin, which were formed from the keratinized layer of the skin rather than outgrowths of the vertebral column or skull [5].

It is important to note that these structures have not previously been recorded and differ significantly from both theropod protofeathers and the spinose scales of modern reptiles. Unlike protofeathers, they show no evidence of branching or filamentous organization. At the same time, they differ from reptilian spines in both structure and developmental origin [6, 7].

Thus, the keratinous spines of *H. dongi* represent a previously unknown type of integumentary structure in dinosaurs [4, 6].

3. Functional interpretation of spines

The presence of such unusual structures in *H. dongi* raises questions regarding their biological function. Several hypotheses have been proposed, including defensive, thermoregulatory, sensory, and display functions [4, 5].

The most strongly supported interpretation is the defensive hypothesis, based on morphological and ecological data. The spines are densely distributed and their tips are oriented backwards, which would have made predatory attacks more difficult. Such an arrangement represents a form of passive defense, as backward-pointing spines could hinder both capture and consumption by predators. Even if a predator succeeded in subduing *H. dongi*, the ingestion process would have been hindered by the sharp keratinous spines, which could injure the oral cavity and the esophagus [5].

A thermoregulatory function is also possible. The presence of hollow protruding structures may have increased the surface area of the body, potentially facilitating heat exchange. This is very important for active dinosaurs with a fast metabolism. However, the relatively low density of spines suggests that this function, if present, was likely secondary [5].

The sensory hypothesis proposes that the spines of *H. dongi* could have functioned as mechanoreceptors detecting vibrations from the surrounding environment or physical contact. However, there is no direct evidence of associated nerve structures, making this interpretation unlikely [5].

Finally, a display function has been considered: the large spines might have been used to repel competitors or attract potential mates. However, the absence of melanosomes in the preserved tissues suggests that the spines were not brightly colored, which reduces the likelihood of their use in visual signaling [4, 5].

Overall, the available evidence most strongly supports a primarily defensive role.

Conclusions

The analysis of *Haolong dongi* provides important new insights into the evolution of ornithischian dinosaur integument. The species exhibits a unique combination of three types of skin structures, including previously unknown hollow keratinous spines.

These spines represent a distinct integumentary feature that is not homologous to either theropod protofeathers or reptilian scales. Functional analysis indicates that their primary role was likely defensive, supported by their orientation and distribution.

The discovery of *H.* demonstrates that the diversity of integumentary adaptations in dinosaurs was significantly greater than previously assumed and highlights the importance of exceptional fossil preservation in reconstructing evolutionary innovations.

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WIND ENERGY: ADVANTAGES AND DISADVANTAGES

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Abstract: The article addresses wind energy, which is one of the most widely used 'green' sources of energy and thus contributes to sustainable development. The work presents an overview of the modern statistical data and facts in the field of renewable energy published by researchers, public health organizations, public and non-governmental organizations promoting green technology based on the latest scientific updates. It describes the main aspects of wind energy, its advantages and disadvantages, application options and ways to deal with possible problems. The author puts an emphasis on the global impact of using wind energy, collecting evidence from different countries and industries.

Keywords: wind energy, turbines, improvement, renewable sources of energy, prospects.

ЭНЕРГИЯ ВЕТРА: ДОСТОИНСТВА И НЕДОЧЕТЫ

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Аннотация: Статья посвящена изучению достоинств и недостатков ветровой энергии, которая является одной из наиболее широко распространённых «зеленых» источников энергии и таким образом способствует устойчивому развитию В работе проведен обзор современных статистических и фактических данных в области возобновляемых источников энергии, представленных учеными, организациями здравоохранения, государственными и общественными организациями, содействующих распространению зеленых технологий, основанных на новейших достижениях науки. Описаны основные аспекты использования энергии ветра, ее преимущества и недостатки, возможности и сферы применения, а также пути

устранения возможных проблем. Автор делает акцент на глобальном влиянии использования энергии ветра, приводя примеры ее применения в самых разных странах и отраслях.

Ключевые слова: ветровая энергия, турбины, совершенствование, возобновляемые источники энергии, перспективы.

Introduction

Due to implementation of sustainable development principles the transition to renewable energy is discussed at all levels by both policymakers and academics, being an integral part of the study of all biological systems [2]. The humanity has to seek for new safe ways to obtain energy because of environmental deterioration. The wind energy is one of them, and the new technology to generate wind energy is wind turbines. Yet, how safe they are? There are many nuances, so we must study them. The future of entire planet depends on our actions at this moment, so we need to find out right now the benefits that accrue from the wind turbines, the harm done to the environment, and what to do about it.

There is an assumption that wind power is the most promising way to produce energy. To test this assumption a literature overview has been conducted and presented in this article.

The purpose of the word is to study the positive and negative consequences of using wind energy and to learn about its advantages over other energy sources, which is relevant due to the popularity of wind energy growing every year. To fulfill the purpose the following tasks were set: to study the applicable international research results on wind power, to give a short overview of the situation worldwide, merits and demerits of the wind power, its prospects and the man’s action plan for the future [1; 2].

1. Statistics

According to IRENA, the global installed capacity of wind power increased 98 times over the past two decades, and the production of wind energy has increased 5.2-fold in the period from 2009 to 2019. The share of wind and solar energy in the world is already 10,7%. In 2021, the total capacity of offshore wind power plants has more than tripled to almost 56 GW, largely due to China. For today we have 743 GW of Wind power capacity. This helps to eliminate 1.1 billion tens of CO_2 emissions. A lot of countries provide themselves with 100% green energy [6].

At this moment, the wind energy is very popular, its effect is always growing and we need to deduce why.

2. Obtaining

How do people harness energy from wind? This process includes conversion of kinetic energy of moving air into electricity using a wind turbine. A modern wind turbine is a steel tower with a height of 70 to 125 meters. There are a generator with a rotor and blades on the top of the turbine. The blades start moving with the help of the wind, then they turn the axis, which is connected to the rotor of the generator. Then kinetic energy transforms into electricity inside the generator. The amount of energy that can be obtained from the wind depends on the size of the turbine and the length of its blades. The output is proportional to the size of the rotor and the cube of the wind

speed. Theoretically, when the wind speed doubles, the potential of wind energy increases eight times. Having studied the device of wind turbines in detail, we can say that their mechanism is not very complicated, and their operation does not require much effort. In addition, there are different types of wind turbines, and scientists are constantly looking for ways to improve the already very effective technology.

3. Advantages

The main advantages of the wind power are:

1. Wind is a free and inexhaustible, easily accessible resource.
2. Production is not accompanied by emissions of CO2 and other gases.
3. Wind farms do not require fuel costs. They produce 85 times more energy than they consume.
4. The wind power industry uses very ergonomic stations that do not require a constant human presence and a lot of space, fitting well into any landscape.
5. This is the most advantageous option for hard-to-reach places.
6. The service life of such a power plant averages 20-30 years, and after its dismantling, no traces remain.

As the technology improved and scaled, costs decreased and power factors increased. As reported by IRENA, between 2010 and 2020, the global weighted average present value of onshore wind power decreased by 56%, from $0.089/kWh to $0.039/kWh. During the same period, the price of newly commissioned offshore wind energy projects decreased by 48% [5]. Having learned about the advantages of obtaining energy from wind, we can conclude that this technology is very effective and surpasses many others.

4. Disadvantages

However, wind power has disadvantages. The main one is wind variability: its strength may not be enough to generate the necessary amount of electricity, and if the wind is too strong, additional braking systems are required. Wind turbines can also pose a danger to birds, although mortality from them is lower than from buildings and power lines. Another problem is related to the recycling of blades made of composite materials. There is also a myth about the harm of low-frequency noise and infrasound from wind turbines. However, studies show that such noises do not pose a danger to humans if the regulatory distance is observed, and no serious evidence of their harm to animals and insects has been found [3; 4].

5. Prospects

According to a number of studies, using wind energy opens up broad prospects for development all over the world [5; 6; 7; 8]. Some of them are listed below.

Sustainability and economics: Wind energy is recognized as the most economical and cleanest source of energy, but the current pace of adoption is not enough to achieve global carbon neutrality by 2050.

Record growth: In 2021, wind power generation increased by 17%. This was facilitated by an increase in capacity from 113 GW in 2020 against 59 GW in 2019.

Market leaders: Onshore wind turbines operate in 115 countries. The main drivers of growth in 2021 were China (almost 70% of the increase), the United States (14%) and Brazil (7%).

Offshore wind energy: Floating turbines are actively developing. In 2021, marine technologies accounted for about 22% of the total global capacity growth.

Government policy and objectives in China: The plan for the 14th five-year plan involves increasing the share of renewable energy sources in electricity production to 33% by 2025.

The situation in the European Union: Despite the introduction of new capacities, in 2021, the actual production in Europe decreased by 3% due to abnormal calm. It is proposed to increase the target share of renewable energy sources from 32% to 40% by 2030.

Energy Island (Denmark): The artificial island project in the North Sea will combine 200 turbines to supply energy to Denmark, Germany, Belgium and Luxembourg.

Denmark’s case: The country is already covering 50% of its electricity needs from wind and plans to achieve full carbon neutrality by 2050.

The situation in the USA: The "Law on Reducing Inflation" has been adopted, which provides for large-scale tax benefits for renewable energy for the next 10 years.

The situation in Russia: The industry is still at its initial stage. Large-scale use is limited by the high cost of energy, and large wind farms currently exist only as projects.

Innovative projects and technologies – Kites (SkySails): The first autonomous commercial system operating at an altitude of up to 400 meters has been created. The technology is already being used to power homes in Mauritius.

6. Ways to Remove Disadvantages

The problems of wind turbine recycling are being partially solved: the company Neowa [7] recycles up to 90% of the plant’s mass and all blades, and an agreement with GE Renewable will allow the components of dismantled turbines to be reused. To reduce bird deaths, it was proposed to paint the blades black, which, according to Norwegian scientists, reduces mortality by 72%. Wind variability can be compensated by upgraded turbines and hybrid power plants [9]. In general, the disadvantages of wind energy already have practical solutions.

Conclusion

To sum it up, the tested assumption has been accepted, and the wind power is indeed the most attractive and economically profitable source of electricity for humans that will be able to replace other sources in the future, even despite its disadvantages. Most importantly, wind energy does not harm the environment. However, both onshore and offshore wind power have huge potential for wider deployment and improvement worldwide. In the future humanity will be able to forget about the problems associated with thermal power forever, as renewable energy sources will be able to replace them completely.

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A STUDY OF THE COMPOSITION OF DIFFERENT BRANDS OF LIQUID SOAP

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Abstract: This study presents a comparative analysis of four popular liquid soap brands: Dolce Milk, Dove, Milana, and Palmolive. The composition of each sample was examined, revealing the presence of potentially harmful substances such as EDTA and ethoxylated surfactants. The acidity (pH) of 50% soap solutions was measured using a pH meter; all samples met the GOST standard (5.0-8.5). Foam formation and stability tests were also conducted. The results show that a higher price does not guarantee a safer formula: the most expensive soap, Dolce Milk, contains more potentially harmful components than the more affordable Milana. Dove soap demonstrated the most balanced composition and physicochemical properties. The study also proposes a method for making liquid soap at home using a soap base, coconut oil, and essential oils.

Keywords: liquid soap, surfactants, sodium laureth sulfate (SLES), pH, foaming.

ИССЛЕДОВАНИЕ СОСТАВА РАЗНЫХ МАРОК ЖИДКОГО МЫЛА

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Аннотация: В этой работе проведён сравнительный анализ состава четырёх популярных марок мыла: «Dolce milk», «Dove», «Milana» и «Palmolive». В работе приведен анализ состава каждого образца, в ходе которого было определено наличие некоторых вредных веществ, таких как EDTA и этоксилированные ПАВ. С помощью pH-метра была измерена кислотность 50% растворов мыла, которая у всех образцов оказалась в пределах нормы по ГОСТу (от 5,0 до 8,5). Также были проведены результаты испытания на образование пены и её стабильности. Результаты показали, что высокая цена не обязательно означает

безопасный состав: самое дорогое мыло «Dolce milk» содержит больше потенциально вредных компонентов, чем более доступное «Milana». По составу и физико-химическим свойствам наибольшую сбалансированность продемонстрировало мыло «Dove». В работе также предлагается способ приготовления жидкого мыла в домашних условиях, используя мыльную основу, кокосовое и эфирные масла.

Ключевые слова: жидкое мыло, поверхностно-активные вещества (ПАВ), лауретсульфат натрия (SLES), pH, пенообразование.

Introduction

Liquid soap is an everyday hygiene product, yet many consumers are unaware of the potential harm caused by certain chemical components in its composition. The choice of soap is often influenced by price, advertising, or brand reputation, rather than by an informed analysis of ingredients. This study aims to fill this gap by examining the composition, acidity, and foaming properties of four popular liquid soap brands.

The aim of this study is to identify the safest and most effective liquid soap among four selected brands, and to develop a simple method for making liquid soap at home.

To achieve this aim, the following tasks were set:

- to conduct a sociological survey to determine the most commonly used soap brands among students;
- to analyze the chemical composition of the selected brands;
- to measure the pH level of each soap;
- to test foam formation and foam stability;
- to compare the results with GOST standards;
- to propose a homemade liquid soap recipe.

Materials and Methods

The study examined four liquid soap brands: Dolce Milk, Dove, Milana, and Palmolive. A sociological survey was conducted among 47 tenth-grade students of MBOU “Gymnasium No. 9” to identify the most popular brands.

The chemical composition of each soap was analysed based on ingredient lists provided on the packaging. The following parameters were measured:

pH level: A 50% solution of each soap was prepared using distilled water. The pH was measured with a portable pH meter (calibrated before use). The results were compared with GOST 29188.2-91 (acceptable range 5.0-8.5) [2].

Foam formation and stability: 50% soap solutions of equal volume were shaken for one minute. The initial foam height (H1) was recorded. After five minutes, the foam height (H5) was measured again. Foam stability was calculated using the formula S = H1 / H5 [1].

All experiments were performed in triplicate, and average values were used.

Results

Sociological survey

The survey showed that the most popular liquid soap brands among respondents are “Dolce Milk,” “Dove,” “Milana,” and “Palmolive” – all belonging to the mid-price

category. The choice of soap is influenced mainly by price and advertising. Most respondents do not pay attention to the composition and are unaware of potentially harmful substances.

Composition Analysis

The ingredient analysis is summarised in Tables 1 and 2.

Table 1. Comparison of Dolce Milk and Dove Compositions

«Dolce milk»	**«Dove»**
Price – 400 rubles	Price – 250 rubles
Water	Water
Main surfactant – SLES (Sodium Laureth Sulfate)	Main surfactant – SLES (Sodium Laureth Sulfate)
Glycerin	Glycerin
Cocamidopropyl Betaine	Cocamidopropyl Betaine
PEG-4, PEG-40, PEG-150 – ethoxylated surfactants	Ethylenediaminetetraacetic acid salt (EDTA) – preservative, causes irritation. PPG-9 – ethoxylated surfactant
Castor oil, coconut extract – natural liquid soap components	Rapeseed oil, coconut extract, sunflower oil, almond oil – natural soap components

Table 2. Comparison of Milana and Palmolive Compositions

«Milana»	**«Palmolive»**
Price – 135 rubles	Price – 376 rubles
Water	Water
Main surfactant – SLES (Sodium Laureth Sulfate)	Main surfactant – SLES (Sodium Laureth Sulfate)
Cocamidopropyl Betaine	Cocamidopropyl Betaine
Ethylenediaminetetraacetic acid salt (EDTA) – preservative, causes irritation.	Ethylenediaminetetraacetic acid salt (EDTA) – preservative, causes irritation. Laureth-4 – ethoxylated surfactant.
	Aloe extract, olive oil – natural liquid soap components

All liquid soap brands studied contain harmful components, but in more expensive alternatives, the aggressive effect of these components is minimized by the presence of natural oils [3]. The price of liquid soap did not directly affect its quality: the most expensive soap, Dolce Milk contains more harmful substances than the cheapest, Milana. The most skin-friendly composition was found in Dove soap, as it contains a large number of different natural oils and extracts [5].

pH Measurement

The pH values of 50% soap solutions are presented in Table 3.

Table 3. pH of liquid soap samples

Brand	**Dove**	**Dolce Milk**	**Palmolive**	**Milana**	**GOST range**
pH	5.69	6.64	6.21	6.78	5.0-8.5

All samples meet the GOST standard [2]. Milana has a pH close to neutral (6.78), making it suitable for most skin types. Dove, with a lower pH (5.69), is ideal for people with dry skin.

Foam Stability and Foaming Ability

Foam height and stability are shown in Table 4.

Table 4. Foaming Properties

Brand	**Dove**	**Dolce Milk**	**Palmolive**	**Milana**	**GOST (stability)**
H1 (cm)	8	6	8	11	
H5 (cm)	13.5	10	10.5	14	
S = H1/H5	0.59	0.6	0.8	0.8	0.8

Only Milana and Palmolive meet the GOST foam stability standard (≥ 0.8). Milana also produces the highest amount of foam.

Making Liquid Soap at Home

Based on literature recommendations, a homemade liquid soap was prepared using:

- 430 ml soap base (containing castor oil, glycerin, cocamidopropyl betaine, citric acid);
- 20 ml water;
- 50 ml coconut oil;
- 2 drops of soap dye;
- 10 drops of lavender essential oil.

All ingredients were thoroughly mixed. The resulting product cleans hands well, softens the skin, and leaves a pleasant lavender scent.

Conclusion

Comparing the composition and properties of the four liquid soap brands, the following conclusions can be drawn:

1. A higher price does not guarantee a better or safer composition. The most expensive brand (Dolce Milk) contains a high number of ethoxylated surfactants, while the cheapest (Milana) has fewer harmful components.
2. The most balanced composition in terms of safety and skin friendliness was found in Dove soap, due to its high content of natural oils.
3. All tested brands comply with GOST pH requirements. Milana has a near-neutral pH, Dove has a slightly acidic pH suitable for dry skin.
4. Only Milana and Palmolive meet the GOST foam stability standard (≥ 0.8). Milana shows the highest foam production.
5. Homemade liquid soap can be an effective, safe, and natural alternative to commercial products.

Based on these findings, consumers are advised to choose liquid soap according to their skin type, pay attention to ingredient lists, and avoid products with excessive ethoxylated surfactants and EDTA when possible. Homemade soap is a viable option for those seeking full control over ingredients.

The findings of this study can be used in educational practice, particularly for students of agricultural universities, to raise their awareness of safe household chemicals and to promote informed consumer behavior [6-8].

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WAYS TO COMBAT PLASTIC POLLUTION

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Abstract: This paper examines the physical and chemical properties of plastic, the scale of its pollution in various environments and different countries, modern methods of waste disposal and recycling, as well as strategies for reducing plastic consumption in everyday life. The analysis also highlights the role of consumer behavior and policy incentives in shaping effective waste management practices. Special attention is given to environmentally safe alternatives to traditional polymers and practical recommendations for schools and local communities. Based on a review of worldwide literature and current initiatives, proposals are formulated for implementing preventive measures aimed at reducing the plastic burden on the environment.

Keywords: plastic, pollution, utilization, recycling, reduced consumption.

СПОСОБЫ БОРЬБЫ С ПЛАСТИКОВЫМ ЗАГРЯЗНЕНИЕМ

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Аннотация: В работе рассматриваются физические и химические свойства пластика, масштабы его загрязнения в различных природных средах и разных странах, современные методы утилизации и переработки отходов, а также стратегии снижения потребления пластика в повседневной жизни. Анализируется роль потребительского поведения и политических стимулов в формировании эффективных практик обращения с отходами. Особое внимание уделяется экологически безопасным альтернативам традиционным полимерам и практическим рекомендациям для школ и местных сообществ. На основе анализа мировых литературных данных и современных инициатив формулируются предложения по внедрению профилактических мер, направленных на уменьшение пластиковой нагрузки на окружающую среду.

Ключевые слова: пластик, загрязнение, утилизация, переработка, снижение потребления.

Introduction

Human activities have been affecting large ecosystems since ancient times. By the middle of the 20th century, environmental changes caused by anthropogenic impact had reached a planetary scale. Environmental pollution has become a global issue: huge amounts of harmful substances are released daily into the atmosphere, water, and soil. One of the most pressing problems is plastic pollution. Society cannot ignore the threat posed by hazardeous chemicals and plastic waste. Reducing and recycling plastic is therefore an urgent necessity.

We hypothesize that existing technologies can significantly mitigate plastic pollution through a combination of reduced consumption, improved recycling methods, and substitution with biodegradable materials.

The purpose of this study is to identify ways to reduce plastic consumption and methods for its recycling.

To achieve this purpose, the following tasks are set:

- to analyze the properties of plastic and its impact on the environment;
- to review the scale of ecosystem pollution by plastic;
- to examine environmentally friendly methods of plastic disposal and its replacement with alternative materials;
- to identify practical measure for reducing plastic consumption by humans.

Materials and Methods

This study is based on a review of scientific literature, official reports, and environmental statistics. Priority was given to official documents of international organizations, and verified statistical data published in the last decade. The collected information was analyzed, systematized, and grouped into thematic sections reflecting the main aspects of the problem: properties of plastic, scale of pollution, waste management technologies, reduction strategies, and alternative materials.

Results

1. Properties of Plastic

Plastic is an artificially created high-strength and elastic material based on polymers — synthetic or natural molecular compounds. Various types of plastics are used to create packaging, tableware, furniture, building materials, clothing, and many other goods. However, regardless of its type, plastic causes significant harm to the ecosystem:

- Plastic production requires a non-renewable resource − crude oil. When interacting with phosgene gas, it not only forms poorly decomposing plastic but also releases a dangerous respiratory irritant.
- Some types of plastics are hazardous. When decomposed, they release chemicals that poison living organisms.

– Biodegradable plastic emits methane, which contributes to the greenhouse effect and, consequently, global warming.

– Plastic waste clogs both terrestrial and aquatic environments. It often causes the death of animals that become entangled in the garbage.

– Plastic products break down into microplastics that take hundreds or even thousands of years to decompose, which increases the likelihood of its accumulation in living organisms.

Thus, plastic pollution is a serious problem that harms humans, animals, and the environment. Despite the advantages of this material, plastic is a threat to the ecosystem.

2. The Scale of Environmental Pollution

A team of scientists from the USA found out [9] that since the 1950s, 8.3 billion tons of plastic have been produced in the world, 6.3 billion tons exist as waste. Only 9% of plastic waste is recycled, while the remaining 79% accumulates in landfills or in the environment.

Total plastic production increased from 2 million tons in 1950 to more than 400 million tons per year in 2015.

A study conducted in 55 countries [4] identified the companies that emit the most plastic waste. The Coca-Cola Company ranked first, folllowed by PepsiCo, Nestle, and Uniliver. The most common type of waste were food packaging and tobacco products.

Earlier this year, it was found [8] that one third of the plastic debris entering the ocean consists of microscopic particles that originate from synthetic clothing or car tires.

Analyzing these data, we can conclude that plastic pollution has reached a planetary scale and the forecasts are alarming. The longer no action is taken, the more severe the environmental pollution will become.

3. Getting Rid of Plastic Waste

What should be done now with the increasing flow of plastic waste to prevent it from hanging on tree branches, floating in ocean gyres, or clogging the stomachs of seabirds and whales?

Today, there are about 500 incinerators in Europe, and about 42 % of plastic waste is incinerated. There are about 300 such waste recycling plants in China.

Modern incinerators use technologies that significantly reduce the formation and release of dioxins. Emission control technology has been added, which reduces the amount of nitrogen oxides and other air pollutants. Modern incinerators also include processes for generating electricity, heating water for district heating services, recycling metals found in ash, and producing building tiles from the remaining slag.

Sophisticated incinerators that burn plastic and other municipal waste can produce enough heat and steam to turn turbine blades and generate electricity for the local grid.

Recycling plastic costs more than incinerating it. It can expose employees to serious health risks. And there are also natural limitations: paper can only be recycled five to seven times; most transparent plastic bottles cannot be converted into new ones, etc.

Currently, pyrolysis is a more attractive technology, in which plastics are crushed and melted in the presence of a small amount of oxygen. Heat decomposes plastic polymers into smaller hydrocarbons that can be processed into diesel fuel and even other petrochemical products, including new plastics. There are currently seven relatively small pyrolysis plants operating in the United States.

We have reviewed the most common ways to get rid of plastic waste. Under improper conditions and algorithms, the disposal of this material can have harmful consequences. However, if everything is done according to regulations, humanity will be able to safely manage plastic waste.

4. Ways to Reduce Plastic Cinsumption

According to a United Nations document [10], 77 countries have adopted some kind of total or partial ban on plastic bags.

China banned thin plastic bags in 2008 and at the same time started charging for more durable bags.

Austria, France, Italy and Denmark have introduced a tax on plastic packaging. The deposit system, which allows consumers to return packaging and use branded recycled packaging, pays for the recycling of glass and cans in the United States and Europe.

In Scandinavian countries, consumers receive cash when they return plastic containers. The Netherlands and Austria impose very high taxes on all garbage in landfills.

On January 1, 2019, the ‘garbage reform’ was launched in Russia [6]. If this trend continues, humanity will be able to forget about the problem of plastic pollution.

5. Eco-friendly Plastic Replacement

Many small and large companies are currently developing a suitable alternative to the material.

The Swedish electric car manufacturer Cake has entered into a partnership agreement with PaperShell to abandon plastic and use a composite made of 100% cellulose created by the company [5]. PaperShell components are as weather-resistant as plastics and as durable as fiber composites, but more environmentally friendly than both. And at the end of their service life, such components can be recycled at existing facilities.

Scientists have created enzymes, a pinch of which can make biodegradable plastic packaging and forks compostable [7].

Scientists from Birmingham and Duke Universities have created a new group of polymers from environmentally friendly sugar alcohols that retain all the qualities of conventional plastics, but are also amenable to decomposition and mechanical processing [7].

The Dutch company Fuenix Ecogy Group has developed a method for converting plastic waste back into oil. According to Fuenix, this technology also reduces carbon dioxide emissions by 65%.

Currently, there are many projects aimed at finding and creating environmentally friendly alternatives to plastic. Despite their number, such projects are still less popular than plastic. Therefore, the most important thing is to popularize the idea of a plastic-free world and invest money in such projects.

Conclusion

In conclusion, plastic pollution remains a critical global issue. The study confirms that modern technologies can effectively reduce plastic pollution.

It is essential to promote plastic reduction, encourage governments and companies to take action, and support businesses that limit, recycle, or replace plastic with environmentally friendly alternatives.

Enhancing environmental literacy, especially among students, is a key priority. Modern educational technologies can greatly expand opportunities to achieve this goal and to encourage sustainable behaviour [1; 2; 3].

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