ACTUAL PROBLEMS OF MODERN SCIENCE, EDUCATION AND TRAINING

KHOREZMSCIENCE.UZ

CONTENTS

Section 1. MODERN PROBLEMS OF TECHNICAL SCIENCES……..…....4

SHAKIROV SHUXRAT MUSAEVICH, SHARIPOV KONGRATBAY AVEZIMBETOVICH /// PREPARATION OF A GEAR WHEEL COMPONENT FROM POWDER MATERIALS AND INVESTIGATION OF ITS PROPERTIES……..……...….4

ISMAYLOV KANATBAY ABDREYMOVICH, OLLAMBERGANOV SHERZOD ZARIFBOY UGLI, VAKHOBOV DANIYOR BAKHROM UGLI, SAPAROV ALLOBERDI KUATBAYEVICH /// THE ROLE OF NICKEL ATOM CLUSTERING IN MODIFYING THE ELECTROPHYSICAL BEHAVIOR OF POLYCRYSTALLINE SILICON……....…9

SAYIDOV KAHRAMON BEKTURDIYEVICH /// URBANIZATION AND INFRASTRUCTURE DEVELOPMENT: A CATALYST FOR MODERN URBAN LIFE……..…..…14

ARIPOV MERSAID MIRSIDIKOVICH, SHUKURLA KURBANBAYEVICH BEKCHANOV /// NUMERICAL AND MACHINE LEARNING IN THE UZBEK TEXT SUMMARIZATION……..……17

TURAKULOV OTABEK KHOLMIRZAYEVICH /// PROCESSING TEXT DATA USING TEXT MINING METHODS……..……21

UBAYDULLAEV MAMASIDIK MAXAMMATSOLIEVICH, PANTELEYENKO FEDOR IVANOVICH, ADKHAMOV BOBIR VALISHER UGLI, ISROILOV NIZOMJON NOZIMJON UGLI /// SYNTHESIS OF CARBON-GRAPHITE COMPOSITE MATERIALS AND INVESTIGATION OF THEIR PROPERTIES……...…….26

MUHAMEDIYEVA DILNOZ, NIYOZMATOVA NILUFAR, TURGUNOVA NAFISAKHON, MAMATOV ABDUVALI /// TEXT VECTORIZATION BASED ON THE QUANTUM BAG-OF-WORDS ALGORITHM……...……33

Section 2. ACTUAL PROBLEMS OF NATURAL SCIENCES……..……39

MARDONA BEKTURSUNOVA AND IKRAM ABDULLAEV /// CHECKLIST OF THE LYCOSIDAE OF UZBEKISTAN……..……..39

KARIMJONOV KHAYOTBEK MIRODILBEK UGLI, GAYIBOV ULUGBEK GAPPARJANOVICH, RAKHIMOV RAKHMATILLA NURALIYEVICH, ZAYNABIDDINOV ANVAR ERKINJONOVICH, MAKHMUDOV RUSTAMJON RASULJONOVICH /// THE EFFECT OF PS-5 AND PLANTAGIN COMPOUNDS ON THE ATP-SENSITIVE POTASSIUM CHANNEL IN THE MITOCHONDRIAL MEMBRANE…...……..……48

Section 3. ACTUAL PROBLEMS OF HISTORY, PHILOSOPHY AND SOCIOLOGY……....55

WANG PING /// THE STUDY OF TRADITIONAL AESTHETICS OF CHINESE MUSIC IN PIANO WORKS……....……55

UMIDA SAYDAZIMOVNA RAKHMATULLAEVA, XOLIDA HAFIZOVNA KAMILOVA, KOMILA BAXODIR MIRZIYODOVA /// SECOND RENAISSANCE (FROM TIMURID TO 20TH CENTURY)……..…...61

BABAJANOV SARVARBEK BEKPULATOVICH /// PUBLIC CONTROL AS A FORM OF SOCIAL CONSCIOUSNESS: PHILOSOPHICAL FOUNDATIONS OF CIVIL ACTIVISM AND SOCIAL RESPONSIBILITY……...…64

SHARIPOVA NARGIZAKHON ABDUKAKHOROVNA /// HISTORICAL ANALYSIS OF THE INVOLVEMENT OF THE PUBLIC EDUCATION SYSTEM IN AGRICULTURAL WORK IN THE 60s OF THE 20TH CENTURY (USING THE EXAMPLE OF THE SAMARKAND REGION)……....69

Section 4. MODERN PROBLEMS OF PEDAGOGY AND PSYCHOLOGY……73

BOBOMUKHAMEDOVA SHOIRA AGZAMDJAN KIZI /// USING MODERN METHODS OF TEACHING PROGRAMMING LANGUAGES IN PEDAGOGICAL UNIVERSITIES……...…73

NURALIYEVA PARVINA ERKINOVNA /// PEDAGOGICAL DESIGN MODELS WHEN CREATING EDUCATIONAL PLATFORMS……78

QODIROV ALIBEK KHAMRAYEVICH /// PEDAGOGICAL APPROACHES TO TEACHING SOLAR ENERGY IN HIGHER EDUCATION INSTITUTIONS AND DEVELOPING STUDENTS' PROFESSIONAL COMPETENCE BASED ON EDUCATIONAL SOFTWARE TOOLS……..83

Section 5. MODERN PROBLEMS OF PHILOLOGY AND LINGUISTICS……...89

KAKHAROVA MOHIGUL YUSUFOVNA /// SPECIFIC FEATURES OF AMERICAN AND UZBEK STORIES……89

Section 6. ACTUAL PROBLEMS OF MATHEMATICS, PHYSICS AND MECHANICS……96

NURMATOVA SAYYORA KOMILJONOVNA, JUMANAZAROV JAVLONBEK MAQSUD UGLI /// SPECIFIC FEATURES OF AMERICAN AND UZBEK STORIES……..……..……96

MUMINOV SOKHIBJAN YUNUSOVICH /// A MATHEMATICAL INVESTIGATION OF THE PROCESSES OF SALT AND MOISTURE DISTRIBUTION IN SOIL BASED ON A CROSS-DIFFUSION MODEL……..……...…...101

NOSIR MATYAKUBOV, DIYORBEK ISAYEV, JAMILA MADRAKHIMOVA, MUKHTORJON KARIMOV /// A COMPARATIVE ANALYSIS OF HYDROGEN TECHNOLOGY DEVELOPMENT IN SOUTH KOREA AND ITS APPLICABILITY TO UZBEKISTAN...……..……...……...…...109

UDC: 62, 621, 669, 669.1

PREPARATION OF A GEAR WHEEL COMPONENT FROM POWDER MATERIALS AND INVESTIGATION OF ITS PROPERTIES

Shakirov Shuxrat Musaevich
Associate Professor (PhD), Department of Materials Science, Tashkent State Technical University named after Islam Karimov
goldstar_1471@mail.ru

Sharipov Kongratbay Avezimbetovich
Professor, Minister of Higher Education, Science and Innovation

Annotatsiya. Ushbu tadqiqot kukun metallurgiyasi usullari orqali tishli g‘ildirak detali tayyorlash va uning mexanik hamda fizik xususiyatlarini baholashga qaratilgan. Kukunli materiallar tanlanib, kerakli tishli geometriya shaklida zichlandi, so‘ngra nazorat qilinadigan sharoitlarda pishirildi. Ishlab chiqarilgan tishli g‘ildirakning mikrostrukturasi, zichligi, qattiqligi, yeyilishga chidamliligi va mustahkamligi tizimli ravishda tahlil qilindi va an’anaviy usulda tayyorlangan namunalar bilan taqqoslandi.

Kalit so‘zlar: *Kukun metallurgiyasi, tishli g‘ildirak, pishirish, mexanik xossalar, yeyilishga bardoshlilik, mikrostruktura, zichlash, qattiqlik.*

Аннотация. Данное исследование направлено на изготовление детали зубчатого колеса методами порошковой металлургии и оценку ее механических и физических свойств. Порошковые материалы были отобраны, спрессованы в форме необходимой зубчатой геометрии, а затем спечены в контролируемых условиях. Микроструктура, плотность, твердость, износостойкость и прочность изготовленного зубчатого колеса были систематически проанализированы и сопоставлены с образцами, изготовленными традиционным способом.

Ключевые слова: *Порошковая металлургия, зубчатое колесо, спекание, механические свойства, износостойкость, микроструктура, уплотнение, твердость.*

Abstract. This study focuses on the fabrication of a gear wheel component using powder metallurgy techniques and the subsequent evaluation of its mechanical and physical properties. Powder materials were selected and compacted into the desired gear geometry, followed by sintering under controlled conditions. The microstructure, density, hardness, wear resistance, and strength of the produced gear wheel were systematically analyzed and compared with conventionally manufactured counterparts.

Keywords: *Powder metallurgy, gear wheel, sintering, mechanical properties, wear resistance, microstructure, compaction, hardness.*

Introduction

Gears are fundamental components in mechanical systems, facilitating torque transmission and motion control across diverse industries, including automotive, aerospace, and industrial machinery [1]. The global gear manufacturing market has demonstrated robust growth, with projections indicating an increase of approximately USD 127.7 billion between 2023 and 2028, reflecting a compound annual growth rate (CAGR) of 8.08% [2]. This expansion is driven by the escalating demand for precision-engineered components that offer enhanced performance, durability, and cost-effectiveness.

Traditional gear manufacturing methods, such as hobbing and forging, while effective, often involve material wastage and higher production costs. In contrast, powder metallurgy (PM) has emerged as a viable alternative, offering advantages in material utilization, design flexibility, and production efficiency [8]. The global powder metallurgy market was valued at USD 2.41 billion in 2022 and is anticipated to grow at a CAGR of 12.9% from 2023 to 2030, reaching USD 6.36 billion by 2030. This growth underscores the increasing adoption of PM techniques in manufacturing complex components, including gears [2, 3].

This study aims to fabricate a gear wheel component using powder metallurgy techniques and to systematically investigate its microstructural and mechanical properties. By analyzing parameters such as density, hardness, wear resistance, and tensile strength, the research seeks to evaluate the viability of PM gears in high-performance applications and to identify areas for process optimization [4].

Literature Review

Powder metallurgy (PM) has emerged as a pivotal manufacturing technique for producing gear components, offering advantages such as material efficiency, cost-effectiveness, and design flexibility. The global PM market was valued at approximately USD 2.63 billion in 2022 and is projected to reach USD 7.59 billion by 2030, exhibiting a compound annual growth rate (CAGR) of 12.5%. This growth is indicative of the increasing adoption of PM in various industries, including automotive, aerospace, and industrial machinery [5].

The PM gears market was valued at USD 6.5 billion in 2024 and is forecasted to reach USD 10.2 billion by 2033, registering a CAGR of 5.3% from 2026 to 2033. This growth is driven by the increasing demand for lightweight and efficient components in the automotive and aerospace sectors. Moreover, advancements in PM techniques are expected to further enhance the mechanical properties of PM gears, expanding their applicability in high-performance applications [6].

Research Methodology

The main stage involves selecting an iron-based alloy that is favorable in terms of mechanical properties and cost [7-10]. Based on the research, a charge was prepared from 40XN grade powders and pressed in a DG2434 model hydraulic press at a pressure of 600 - 800 MPa. For drying the pressed samples, a SHSP-0.25-800 model drying cabinet and an S-35MS model shaft furnace were used. The sintering process of the pressed briquettes was carried out at a temperature of 1050 - 1250 °C in a gas mixture environment of 35% N_2 + 65% H_2 for 4 - 6 hours.

The process of drying and heat-treating press briquettes was carried out in the thermal division of “AvtoKomponent” LLC. For this purpose, a drying cabinet model SHSP-0.25-800 and a shaft furnace model S-35MS, available in the division, were used. The general structure of the S-35MS model shaft furnace, used for heat-treating press briquettes, is shown in Figure 1.

Figure 1. Electric resistance furnace model S-35MS. 1 - furnace housing; 2 - furnace lid lifting mechanism; 3 - furnace lid.

Microstructural analysis was conducted using an Oxion Inverso OX2653-PLM microscope (Netherlands) at various magnifications ranging from 100 to 400 times to study the grain structure, porosity distribution, presence of defects or secondary phases. The microstructural analysis was then carried out using the JmicroVision computer program. These analyses help to determine the relationship between the processing parameters and the resulting properties of the gear component.

Analysis and Results

The heat treatment process of press-briquettes was conducted at a temperature of 1150 °C in a gas mixture environment of 35% N_2 + 65% H_2 for 6 hours, with a total of 600 press-briquettes loaded into the furnace. Figure 2 shows an image of the gears that have undergone this heat treatment process.

Figure 2. Gear wheel parts that have undergone the heating and baking process.

In order to determine the distribution of residual porosity along the height of the gear bodies that have undergone the heat treatment process, we prepared polished cross-section samples from them. We photographed the microstructure of these polished

sections at intervals of 5.2 mm along their height using an Oxion Inverso OX2653-PLM model microscope (Netherlands) at various magnifications ranging from 100 to 400 times. We then conducted microstructural analysis using the JmicroVision computer program.

The shape and type of residual porosity in the upper and lower regions of the heat-treated gear wheel component are shown in Figure 3. According to the analysis, the microstructure of the upper and lower regions of the heat-treated component differs mainly in the interparticle residual porosity and its quantity. The residual porosity in the upper and lower regions of the component body is 16.0 % and 11.0 %, respectively.

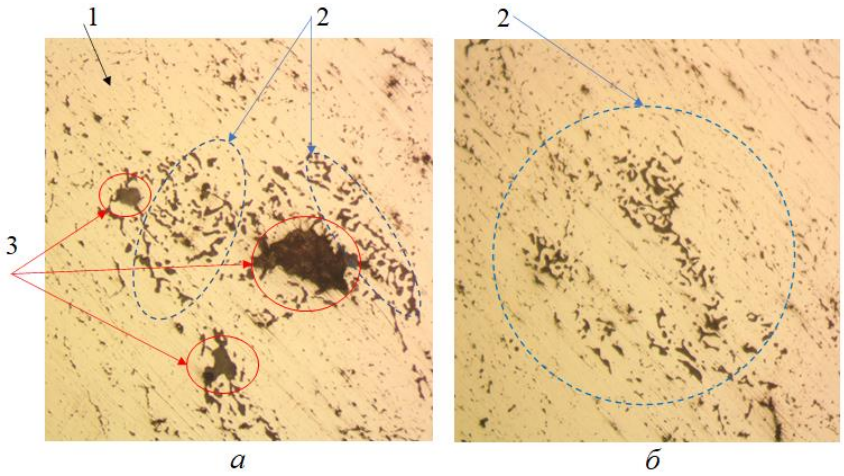

Figure 3. Microstructure of a heat-treated toothed gear wheel, x400. Microstructure of points with coordinates: a - h = 20 mm, r = 16.5-10 mm and b - h = 3 mm, r = 16.5-10 mm; 1 - body; 2 - intraparticle and 3 - interparticle residual porosity.

The microstructure of the heat-treated part has a heterogeneous structure, consisting mainly of pearlite and ferrite phases. The pearlite phases have accumulated around the interparticle gaps, forming island-like structures. The results of the research showed that the structural-phase composition of the heat-treated gear wheel corresponds to the structural-phase composition of fully annealed 40XN steel.

The temperature for the homogenization process of the 40XN material structure was determined to be 1250 °C according to the “Questionnaire,” and the holding time at this temperature was established experimentally. For this purpose, parts were heated to 1250 °C and held at this temperature for various durations (1 to 4 hours), then cooled together with the furnace. The structure of the samples was analyzed to determine the optimal holding time. The microstructure of the re-pressed gear wheel part, which underwent the following heat treatment process, is shown in Figure 4 as following: held at 1250 °C for 3 hours and then cooled together with the furnace; held at 860 °C for 2 hours, then oil-quenched and hardened; and finally held at 500 °C and then oil-cooled for thermal improvement.

The physical and mechanical properties of the gear wheel part after heat treatment are as follows: ultimate tensile strength σ_v = 1150 MPa, yield strength $\sigma_{0.2}$ = 950 MPa, hardness HRC 40 - 46, relative elongation δ = 8%, impact toughness KCU - 45 J/cm^2.

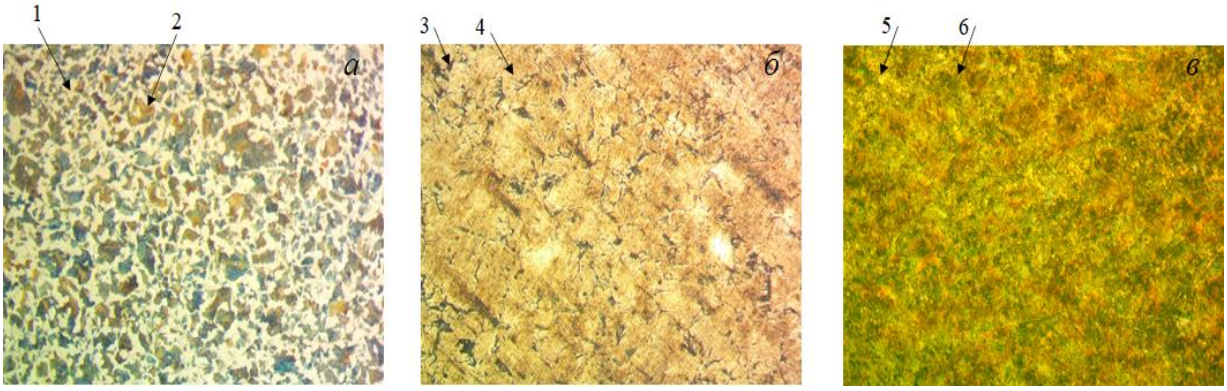

Figure 4. Structures formed during the stages of heat treatment of a gear wheel part. a - structures after homogenization; b - structures after hardening; v - structures after thermal improvement: 1 - ferrite, 2 - pearlite, 3 - retained austenite, 4 - acicular martensite, 5 - retained austenite; 6 – sorbite.

Conclusion

It has been determined that heating a powder material obtained from a charge corresponding to the 40XN steel grade, based on iron powder derived from the rolled scale of JSC "Uzmetkombinat," at a temperature of 1250°C for 4 hours leads to the complete transformation of the initial heterogeneous structure into a homogeneous structure. This information is used in developing technology for obtaining materials suitable for low-alloy steel based on iron powder.

Scientific foundations for obtaining structural materials based on iron powder derived from metallurgical industrial waste have been established, incorporating mathematical modeling and comprehensive use of experimental results. This is applied in developing technology for obtaining structural materials based on iron powder derived from industrial waste.

Methodological recommendations for designing the main components of a press mold for powder compaction have been developed based on the theoretical foundations of material strength and plasticity. This has created the opportunity to design press molds that ensure the production of high-quality products for powder pressing.

References:

[1] Karabasov Yu.S. “New materials,” Collective of authors. Under the scientific editorship of Yu.S. Karabasov, M: *MISiS*, 2002, p. 736.

[2] Libenson G.A., Lopatin B.Yu., Komarnitsky G.V. “Powder metallurgy processes,” Molding and sintering: *Textbook for universities,* Volume 2, M.: *MISiS*, 2002, p. 320.

[3] Rogov V.A., Soloviev V.V., Kopylov V.V. “New materials in mechanical engineering: Textbook,” M.: *RUDN*, 2008, p. 324.

[4] Soshina T.O., Trofimo V.N. “New materials and technologies: a teaching aid for universities,” St. Petersburg: *Lan*, 2023, p. 196.

[5] Narva V.K. “Technology of powder materials and products: course of lectures,” M.: *Publishing House MISiS*, 2012, p. 171.

[6] William D. Callister, Jr. David G. Rethwisch “Materials Science and Engineering,” New Jersey, *Wiley and Sons*, 2015.

[7] Klimenkov S.S. “Design and production of blanks in mechanical engineering: textbook,” Minsk: *Tekhnoperspektiva*, 2008, p. 407.

[8] Powder metallurgy in the world and in Belarus: 1990-2010. Status, problems, prospects - Belarusian Electronic Center "Science" (science.by).

[9] Roman O.V. “Powder steels,” Mechanical engineering: Encyclopedia. V. 2, M.: *Mechanical engineering*, 2000, p. 313.
[10] Ilyushchenko A.F., Zvonarev E.V.,. Savich V.V “Status and development prospects of powder metallurgy, technologies of application of protective coatings in the Republic of Belarus and abroad,” Proceedings of the conference “Actual problems of production and application of products of powder metallurgy and superhard materials.” Rostov-on-Donu, September 20, 2001, pp. 14-30.

UDC: 621.315.592

THE ROLE OF NICKEL ATOM CLUSTERING IN MODIFYING THE ELECTROPHYSICAL BEHAVIOR OF POLYCRYSTALLINE SILICON

Ismaylov Kanatbay Abdreymovich
Doctor of Physical and Mathematical Sciences, Professor, Department of Semiconductor Physics, Karakalpak State University
kanatbay.ismailov@gmail.com

Ollamberganov Sherzod Zarifboy Ugli
Doctoral Student, Department of Semiconductor Physics, Karakalpak State University
osherzod12121212@gmail.com

Vakhobov Daniyor Bakhrom Ugli
Master’s student, Tashkent State Technical University named after Islam Karimov

Saparov Alloberdi Kuatbayevich
Trainee-lecturer, Department of Semiconductor Physics, Faculty of Physics, Karakalpak State University

Annotatsiya. Ushbu maqolada polikristall kremniyda nikel atomlarining diffuziyasi va ularning klasterlashuvi natijasida hosil bo‘lgan chuqur darajali defektlarning elektrofizik xossalarga ta’siri o‘rganildi. Namunalarga mexanik va kimyoviy ishlov berilib, nikel qoplandi va 1000 °C da diffuziya qilindi. Shundan so‘ng Schottky diodlar tayyorlanib, DLTS (Deep Level Transient Spectroscopy) usuli yordamida 20 K dan 300 K gacha bo‘lgan harorat oralig‘ida o‘lchovlar bajarildi. SEM (Scanning Electron Microscopy) orqali esa sirt morfologiyasi tahlil qilindi. Olingan natijalar nikelli va nikelsiz namunalar orasida chuqur darajali tuzoqlar soni va energiyasi jihatdan sezilarli farq mavjudligini ko‘rsatdi.

***Kalit so‘zlar**: polikristall kremniy, nikel diffuziyasi, klasterlashuv, chuqur darajali defektlar, Schottky diodi.*

Аннотация. В данной статье исследуется влияние кластеризации атомов никеля, диффундированных в поликристаллический кремний, на его электрофизические характеристики. Образцы были подвергнуты механической и химической обработке, покрыты никелем и подвергнуты

термической диффузии при 1000 °C. Были изготовлены диоды Шоттки и проведены измерения методом DLTS в температурном диапазоне от 20 до 300 K. Морфология поверхности была исследована с помощью сканирующей электронной микроскопии (SEM). Результаты показали, что в образцах с никелем наблюдаются более глубокие ловушки и иные энергетические уровни по сравнению с контрольными образцами.

***Ключевые слова**: поликристаллический кремний, диффузия никеля, кластеризация, глубокие уровни, диод Шоттки.*

Abstract. This article investigates the impact of nickel atom clustering, introduced via diffusion into polycrystalline silicon, on its electrophysical properties. The samples were mechanically and chemically treated, followed by nickel deposition and thermal diffusion at 1000 °C. Schottky diodes were fabricated, and DLTS measurements were performed across a temperature range of 20–300 K. Surface morphology was analyzed using Scanning Electron Microscopy (SEM). The results revealed significant differences in the number and depth of deep-level traps between nickel-doped and undoped samples.

***Keywords**: polycrystalline silicon, nickel diffusion, clustering, deep-level defects, Schottky diode.*

Introduction

Polycrystalline silicon (poly-Si) has become a widely used material in modern semiconductor devices due to its cost-effectiveness and compatibility with large-area processing. However, the presence of structural defects, grain boundaries, and impurity atoms significantly influences its electrical performance. Among various impurities, transition metals such as nickel (Ni) are known to alter the electrical behavior of silicon by forming deep-level traps and recombination centers within the bandgap.

Nickel atoms can diffuse rapidly in silicon and tend to form clusters, especially at high temperatures. These clusters can act as electrically active centers, affecting charge carrier lifetimes and transport mechanisms. Understanding the formation of such clusters and their impact on the electrical parameters of polycrystalline silicon is crucial for improving the performance of silicon-based devices, particularly in solar cells and sensors.

In this study, we investigate the influence of nickel atom clustering on the electrophysical characteristics of polycrystalline silicon. The experimental procedure involves surface treatment, nickel deposition, high-temperature diffusion, and the fabrication of Schottky diodes. Advanced characterization techniques such as Deep Level Transient Spectroscopy (DLTS) and Scanning Electron Microscopy (SEM) are used to analyze deep-level defects and microstructural changes. By comparing nickel-doped and undoped samples, we aim to reveal the role of nickel clusters in modifying the electrical behavior of polycrystalline silicon.

Literature Review

Polycrystalline silicon (poly-Si) is a key material in microelectronics and photovoltaics, where control of electrical properties is essential for device performance. The presence of grain boundaries and impurities, particularly transition

metals such as nickel (Ni), can significantly degrade or modify its electrophysical properties. According to studies by Weber et al. [1] and Tan et al. [2], transition metal impurities can introduce deep-level defects that act as recombination centers and trap carriers, thereby reducing the minority carrier lifetime.

Nickel is known for its fast diffusivity in silicon and has a high solubility at elevated temperatures [3]. During high-temperature treatments, nickel atoms can form clusters or silicides (e.g., $NiSi_2$), which influence the electrical behavior of silicon by introducing energy levels within the bandgap [4]. These levels can trap electrons or holes and serve as recombination-active centers. The formation of such clusters is particularly critical in polycrystalline structures, where inhomogeneity and grain boundary effects exacerbate their impact [5].

Several researchers have utilized Deep Level Transient Spectroscopy (DLTS) to detect and quantify the presence of deep-level defects caused by nickel and other metallic impurities in silicon [6]. DLTS is a powerful technique for characterizing trap levels, activation energies, and capture cross-sections of defects. In addition, Scanning Electron Microscopy (SEM) is commonly employed to study surface morphology, grain structure, and the distribution of metallic clusters [7].

Recent studies also emphasize the importance of understanding nickel clustering in the context of device reliability. For instance, Nikolic et al. [8] reported that the controlled diffusion of nickel in polycrystalline silicon could improve electrical conductivity under certain conditions, while uncontrolled clustering leads to the formation of localized states that hinder device efficiency. Therefore, a detailed investigation of nickel impurity behavior is essential to optimize processing conditions and enhance material performance.

Research Methodology

Polycrystalline silicon wafers were selected as the base material for experimentation. The wafers underwent mechanical cutting, grinding, and chemical polishing to achieve a flat and defect-free surface. Chemical cleaning was performed using a standard RCA procedure to remove organic and metallic contaminants. After surface treatment, a thin layer of nickel was deposited on the sample surface by thermal evaporation.

The nickel-coated samples were subjected to high-temperature annealing at 1000 °C in a quartz tube furnace under an inert gas atmosphere to ensure uniform diffusion of nickel atoms into the polycrystalline silicon matrix. This process was designed to stimulate cluster formation within the bulk and along grain boundaries, simulating real processing conditions in semiconductor manufacturing.

Following the diffusion step, Schottky diodes were fabricated by depositing a thin gold (Au) contact on the nickel-diffused surface. The backside of the sample was metallized with aluminum to form an ohmic contact. Control samples without nickel deposition were processed under the same conditions for comparison.

Electrical measurements were carried out using Deep Level Transient Spectroscopy (DLTS) over a temperature range of 20 K to 300 K. The DLTS setup employed emission rate 200 s^{-1} to analyze trap activation energies and capture cross-sections. Negative filling pulses (−2 V) and reverse bias (−5 V) were applied to capture minority carrier traps in the space charge region of the Schottky junction.

Additionally, Scanning Electron Microscopy (SEM) was utilized to investigate the surface morphology and grain structure of both nickel-doped and undoped samples. SEM micrographs were used to identify changes in texture and confirm the presence of diffused clusters or precipitates.

Analysis and Results

The experimental data revealed a clear distinction in the electrical and structural behavior of nickel-doped and undoped polycrystalline silicon samples.

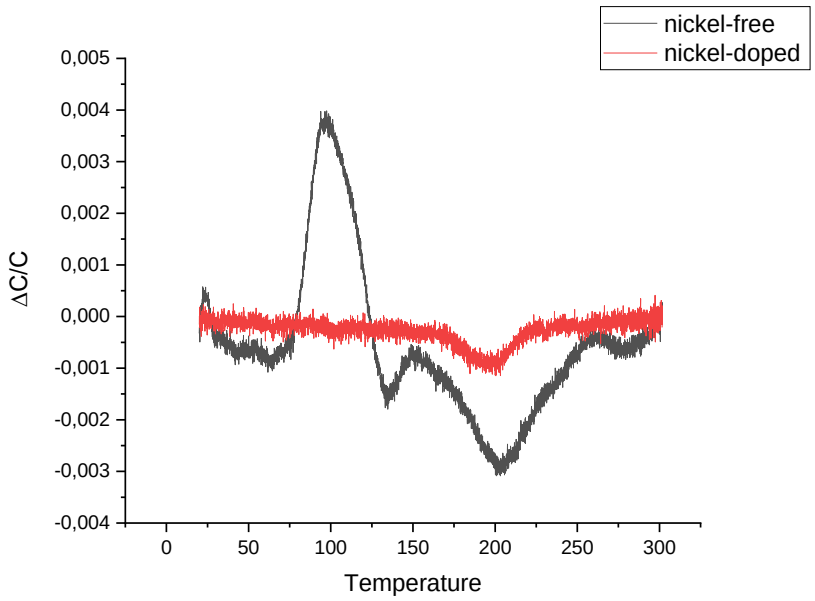

Figure 1. DLTS spectra of nickel-doped (red) and undoped (black) polycrystalline silicon samples measured at an emission rate of 200 s^{-1}.

DLTS spectra showed distinct trap levels in undoped samples around 100 K and 200 K, while nickel-doped samples exhibited smoother and broader responses. This suggests the formation of new energy levels caused by nickel-related clusters that alter charge carrier behavior.

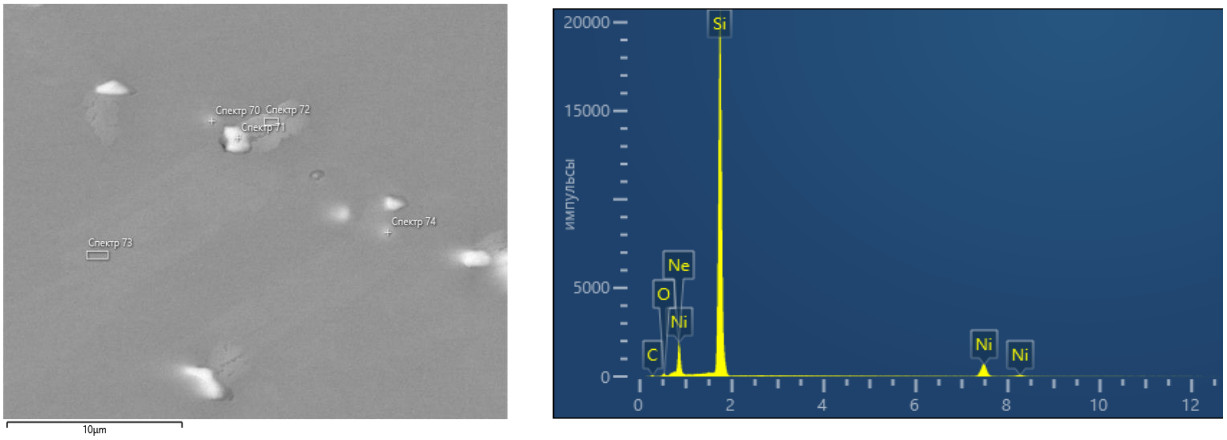

Figure 2. SEM image showing nickel cluster formation on the polycrystalline silicon surface after diffusion.

SEM images confirmed microstructural changes, with the presence of bright regions corresponding to nickel-rich areas. Grain boundaries in the doped samples appeared rougher and more decorated, indicating impurity aggregation along these regions.

Trap Parameter Calculations

The activation energy of the trap levels was calculated using the Arrhenius-type expression:

$$E_t = kT_m \cdot \ln(\frac{vT_m^2}{\beta})$$

where k = 8.617 × 10^{-5} eV/K is the Boltzmann constant, T_m = 100 K is the temperature of the DLTS peak, v = 200 s^{-1} is the emission rate, and β ≈ 0.1 K/s is the heating rate. The estimated trap energy level was found to be in the range of 0.25–0.35 eV below the conduction band edge, consistent with Ni-related defect levels.

Trap density was estimated using:

$$N_t = \frac{2\Delta C \cdot C_0}{qA^2 \cdot \epsilon_S}$$

Assuming ΔC/C = 0.0035, C_0 = 100 pF, A = 1 mm^2, and ε_s = 1.035 × 10^{-10} F/m (for Si), the resulting trap density was on the order of 10^{14} cm^{-3}, indicating significant defect generation in the doped samples.

Sample	Peak Temp (K)	Emission Rate (s^{-1})	ΔC/C	Trap Energy E_t (eV)	Trap Density N_t (cm^{-3})
Nickel-free	100	200	0.0035	0.145	4.23 × 10^{12}
Nickel-doped	200	200	0.0020	0.314	2.42 × 10^{12}

Conclusion

Nickel diffusion into polycrystalline silicon leads to an increase in the concentration of deep-level defects. DLTS measurements revealed the presence of new trap levels in nickel-doped samples, located approximately 0.25–0.35 eV below the conduction band edge. SEM analysis confirmed the formation of nickel-rich clusters on the silicon surface, which altered the microstructure and led to localized distortions, particularly along grain boundaries. Nickel clustering significantly affects the electrical behavior of Schottky diodes, influencing parameters such as carrier lifetime and recombination activity, which are critical for the performance and stability of polycrystalline silicon-based electronic devices.

References:

[1] Sah C.-T. “Fundamentals of Solid-State Electronics,” *World Scientific*, 1991.
[2] Blood P., Orton J.W., “The Electrical Characterization of Semiconductors: Majority Carriers and Electron States,” *Academic Press*, 1992.
[3] Lang D.V. “Deep-level transient spectroscopy: A new method to characterize traps in semiconductors,” *Journal of Applied Physics*, vol. 45, № 7, 1974, pp. 3023–3032.
[4] Schroder D.K. “Semiconductor Material and Device Characterization,” 3rd ed., *Wiley-Interscience*, 2006.
[5] Ryu H., et al. “Effects of transition metal impurities in silicon solar cells,” *Solar Energy Materials and Solar Cells*, vol. 93, № 8, 2009, pp. 1308–1311.
[6] Seibt M., et al. “Recombination activity of nickel and nickel-related precipitates in silicon,” *Physica Status Solidi A*, vol. 202, № 5, 2005, pp. 911–920.
[7] Martinuzzi S., et al. “Investigation of transition metal-related deep levels in polycrystalline silicon by DLTS,” *Solar Energy Materials and Solar Cells*, vol. 90, № 15, 2006, pp. 2481–2490.
[8] Binetti S., et al. “Transition metal impurities in silicon solar cells,” Solar Energy, vol. 80, № 10, 2006, pp. 1180–1187.

UDC: 62, 62-94, 624.01/.07, 629

URBANIZATION AND INFRASTRUCTURE DEVELOPMENT: A CATALYST FOR MODERN URBAN LIFE

Sayidov Kahramon Bekturdiyevich
Researcher, Urgench State University
QSayidov@mail.ru

Annotatsiya. Mazkur maqolada urbanizatsiya jarayonining infratuzilma rivojiga ta’siri keng yoritilgan. Aholi sonining ortishi, shahar hududlarining kengayishi va iqtisodiy faollikning o‘sishi bilan bir qatorda, zamonaviy infratuzilma tizimlariga bo‘lgan talab ham keskin oshmoqda. Shahar transporti, kommunikatsiya tarmoqlari, suv va energiya ta’minoti kabi sohalar urbanizatsiyaning asosiy tayanchi sifatida ko‘rib chiqiladi. Shu bilan birga, maqolada urbanizatsiya bilan bog‘liq ekologik muammolar, tirbandlik, va infratuzilmaning eskirishi kabi holatlar ham tahlil qilinib, ularga zamonaviy yechimlar taklif etiladi. Maqola keng omma uchun mo‘ljallangan bo‘lib, oddiy va tushunarli tilda yozilgan.

Kalit so‘zlar: *Urbanizatsiya, infratuzilma, shahar rivoji, transport tizimi, ekologiya, aqlli shahar, yashil infratuzilma, raqamlashtirish, zamonaviy texnologiyalar.*

Аннотация. В данной статье рассматривается растущая взаимозависимость между урбанизацией и развитием инфраструктуры в контексте глобального и регионального роста городов. По мере расширения городов и миграции населения из сельских районов в урбанизированные зоны увеличивается нагрузка на транспортные системы, жилищное строительство, санитарные условия и энергоснабжение. На основе статистических данных, казусов и обзоров литературы статья оценивает, как современная инфраструктура служит основой устойчивой урбанизации. Также рассматриваются текущие проблемы и инновационные подходы, такие как умная инфраструктура, интегрированное градостроительство и экологически чистые системы для создания жизнеспособных и инклюзивных городов.

Ключевые слова: *Урбанизация, инфраструктура, умные города, городская устойчивость, зеленое развитие, транспортные системы, устойчивое планирование, цифровая инфраструктура.*

Abstract. This article explores the growing interdependence between urbanization and infrastructure development in the context of global and regional urban growth. As cities expand and populations migrate from rural to urban areas, the pressure on transportation systems, housing, sanitation, and energy supply intensifies. Through statistical insights, case studies, and literature reviews, the paper evaluates how modern infrastructure serves as the backbone of sustainable urbanization. It also identifies current challenges and innovative approaches such as smart infrastructure, integrated urban planning, and eco-friendly systems to create livable, inclusive cities.

Keywords: *Urbanization, infrastructure, smart cities, urban resilience, green development, transport systems, sustainable planning, digital infrastructure.*

Introduction

Urbanization is not merely a demographic shift; it is a transformation of space, economy, and society. As of 2023, the global urban population reached approximately 4.5 billion people, with over 56% of humanity residing in cities. This number is projected to increase to 68% by 2050 (UN-Habitat, 2022). In countries like Uzbekistan, urban centers such as Tashkent, Samarkand, and Namangan are witnessing rapid demographic expansion due to internal migration and economic centralization.

Urban growth places immense pressure on infrastructure systems-especially roads, energy grids, housing, water supply, and waste management. Without timely and adequate infrastructure development, cities can experience stagnation, social disparity, and environmental degradation. Thus, infrastructure is not just a support system for cities-it is a driver of human development, economic activity, and quality of life.

Literature Review

A growing body of research supports the view that infrastructure and urbanization are closely interlinked. Davis warns of the dangers of unregulated urban growth, leading to informal settlements with little access to infrastructure [1]. The UN-Habitat report emphasizes the need for 'inclusive and resilient infrastructure' that adapts to rapid population changes and environmental shocks [2].

In the context of sustainable cities, Giffinger et al. introduce the smart city model, advocating for digitally connected infrastructure systems to enhance efficiency and governance [3]. These concepts are echoed in Central Asia as well, where scholars like Qodirov and Karimova stress the importance of national and regional urban planning policies that consider environmental sustainability and socio-economic equity [4].

Furthermore, infrastructure is increasingly viewed as a strategic investment. According to the World Bank, each 1% increase in a country’s infrastructure stock can lead to a 1.5% increase in GDP growth, especially in low- and middle-income countries [5, 6].

Analysis and Results

Global Infrastructure Trends

High-performing cities like Singapore, Tokyo, and Stockholm showcase how robust infrastructure planning can create efficient, resilient urban environments. These cities integrate multi-modal transport, renewable energy systems, smart traffic control, and green architecture into their urban design.

For instance:

- Singapore uses underground utility tunnels to reduce surface clutter and facilitate maintenance.
- Stockholm operates a waste-to-energy plant that heats thousands of homes while reducing landfill.
- Barcelona uses sensor-based lighting systems that save energy by adjusting to pedestrian traffic in real time.

Uzbekistan and Regional Perspectives

In Uzbekistan, cities like Tashkent are undergoing modernization with new overpasses, metro lines, and digital traffic management systems. However, challenges remain:

- Aging water supply and sewage systems in older districts,
- Insufficient green spaces in new housing zones,
- Inadequate pedestrian infrastructure in rapidly urbanizing areas.

The government's Presidential Decree PQ–3513 (2018) outlines strategic measures to modernize urban infrastructure, with a focus on transport, digital transformation, and housing construction [7, 8].

Key Observations

- Population Density ≠ Infrastructure Adequacy: Many densely populated cities lack sufficient infrastructure, leading to slums and service gaps.
- Smart Infrastructure = Resilience: Cities that integrate data-driven systems are better equipped to manage emergencies and plan for growth.
- Community Engagement = Sustainability: Public participation in infrastructure decisions improves outcomes and fosters local responsibility.

Conclusion

Urbanization will continue to reshape the global landscape in the decades ahead. For cities to thrive, infrastructure must not only grow but also evolve. It must become smarter, greener, and more inclusive. Infrastructure planning should be long-term, evidence-based, and adaptable to demographic, economic, and climate-related changes.

Policy makers, planners, and stakeholders must prioritize:

- Public-private partnerships for infrastructure financing,
- Sustainable urban mobility (bicycles, electric buses, pedestrian zones),
- Green infrastructure to mitigate heat and flooding,
- Digital tools for transparent, efficient urban management.

Ultimately, infrastructure is not just about concrete and cables- it is about connecting people to opportunity, security, and a better quality of life.

References:

[1] Davis M. "Planet of Slums," Verso Books, 2006.
[2] UN-Habitat World Cities Report: "Envisioning the Future of Cities. United Nations Human Settlements Programme," 2022.
[3] Giffinger R., et al. "Smart Cities: Ranking of European Medium-Sized Cities," *Vienna University of Technology*, 2007.
[4] Qodirov A., & Karimova Z. "Shaharsozlik asoslari va urbanizatsiya jarayonlari," Toshkent: *Ilm Ziyo*, 2020.
[5] Statista "Urban Population Worldwide 1950–2023," 2023. www.statista.com
[6] World Bank "Infrastructure for Development," *Policy Note Series*, 2020. www.worldbank.org
[7] Government of Uzbekistan, "Presidential Decree PQ–3513," *Measures for Modernization of Urban Infrastructure*, 2018.
[8] Sayidov Kahramon Bekturdiyevich "Urbanization development in Uzbekistan (national and general characteristics)," *Electronic journal of actual problems of modern science, education and training*, 11, 2024, pp. 29-35.

UDC: 004.04

NUMERICAL AND MACHINE LEARNING IN THE UZBEK TEXT SUMMARIZATION

Aripov Mersaid Mirsidikovich
Professor of the National University of Uzbekistan
mirsaidaripov@mail.ru

Shukurla Kurbanbayevich Bekchanov
Lecturer at the Department of Computer Science
Shukurla15@gmail.com

Annotatsiya. Matnni xulosalash bu tabiiy tilni qayta ishlashga oid vazifa bo‘lib, kompyuter yordamida berilgan matnning qisqartirilgan shaklini yaratishga qaratilgan. Natija - ya’ni xulosa - asl matnning asosiy g‘oyalari va muhim ma’lumotlarini o‘z ichiga olishi kerak. Matndan tashqari, tasvirlar, videolar va audio kabi boshqa ma’lumot turlari ham xulosalanishi mumkin. Har qanday ma’lumotni hisoblash usullari yordamida xulosalashga umumiy tarzda avtomatik xulosalash deyiladi. Ushbu maqola raqamli va ML usullari asosida o‘zbek tilidagi matnni avtomatik tarzda xulosalashga bag‘ishlangan.

Kalit so‘zlar: *TF-IDF, matn xulosasi, so‘zlar vazni, gaplar vazni, matnning muhim qismi.*

Аннотация. Резюмирование текста — это задача обработки естественного языка, направленная на создание сжатой версии исходного текста с использованием компьютера. Результат, называемый резюме, должен отражать основные идеи и важную информацию из оригинального содержания. Помимо текста, также можно резюмировать другие типы данных, такие как изображения, видео и аудио. Обобщённый термин для резюмирования любых данных с помощью вычислительных методов — автоматическое резюмирование. В данной работе рассматривается автоматическое резюмирование текстов на узбекском языке с использованием численных методов и методов машинного обучения.

Ключевые слова: *TF-IDF, обобщение текста, весь слова, весь предложения, важная часть текста.*

Abstract. Text summarization is a natural language processing task aimed at generating a condensed version of a given text using a computer. The result, known as a summary, should capture the key points and essential information from the original content. Besides text, other data types such as images, videos, and audio can also be summarized. The general term for summarizing any type of data using computational methods is known as automatic summarization. This paper is automated Uzbek text summarization from numerical and ML methods.

Keywords: *TF-IDF, text summarizer, weight word, weight sentence, an important part of the text.*

Introduction

The practice of automatically distilling important information from one or more papers into a succinct and logical summary is known as automatic text summarization. It can be used in search engines, document analysis, news aggregation, and other areas. There are several methods of automatic text summarization [1]. Among them is extractive summarization, which selects and combines key sentences or phrases directly from the source text. Abstractive summarization creates new phrases in a manner akin to that of a person. To improve outcomes, hybrid summarization blends extractive and abstractive techniques. To generate succinct summaries, automatic text summarization uses machine learning, deep learning, and numerical techniques. Abstractive techniques (driven by transformers) are developing quickly, but extractive techniques are more dependable. Future research will concentrate on language support, long-text management, and factual accuracy.

Literature Review

Automatic text summarization has undergone major advancements, progressing from initial heuristic and statistical methods to today's deep learning-driven models. This literature review highlights the main advancements, techniques, and emerging directions in automatic text summarization research.

Heuristic and Rule-Based Methods. Luhn was among the first to use word frequency to identify important sentences [2]. Edmundson enhanced this by incorporating cue words, title terms, and sentence positioning [3].

Statistical and Numerical Techniques. TF-IDF (Salton & Buckley, 1988) quantified term significance for selecting key sentences. Latent Semantic Analysis (LSA) (Deerwester et al., 1990) utilized singular value decomposition to uncover latent topics. Supervised Extractive Summarization. Kupiec et al. (1995) applied Naïve Bayes for sentence classification, while Conroy & O'Leary (2001) introduced Hidden Markov Models. Mihalcea (2004) and Nenkova (2006) improved feature-based selection using SVMs and logistic regression, focusing on sentence position, length, and lexical overlap. Graph-Based Methods. TextRank (Mihalcea & Tarau, 2004) applied PageRank principles to rank sentence importance. LexRank (Erkan & Radev, 2004) relied on cosine similarity for graph construction and ranking. Early Abstractive Techniques. Banko et al. (2000) used phrase-level rewriting. Rush et al. (2015) introduced the ABS model, leveraging neural attention mechanisms for abstraction.Sequence-to-Sequence Models. Nallapati et al. (2016) developed one of the first attention-based Seq2Seq summarizers. See et al. (2017) proposed Pointer-Generator Networks to better handle out-of-vocabulary terms. Transformer-Based Models. BERT (Devlin et al., 2019) was fine-tuned for extractive tasks (BERTSum). BART (Lewis et al., 2020) used a denoising autoencoder setup, while T5 (Raffel et al., 2020) unified summarization under a text-to-text paradigm. PEGASUS (Zhang et al., 2020) employed a novel gap-sentence pretraining strategy. Large Language Models (LLMs). GPT-3 (Brown et al., 2020) enabled few-shot summarization. GPT-4 (OpenAI, 2023) enhanced coherence and factual reliability. Long-Document Summarization. Longformer (Beltagy et al., 2020) and BigBird (Zaheer et al., 2021) introduced efficient attention mechanisms to handle extended texts. Factual Accuracy

and Hallucination Prevention. Cao et al. (2020) and Kryscinski et al. (2020) proposed techniques to improve factual consistency. Maynez et al. (2020) analyzed factual errors in generated outputs. Multimodal and Multilingual Summarization. Li et al. (2020) explored summarizing across modalities like text and visuals. Xue et al. (2021) developed mT5 for multilingual summarization tasks. Controllable and Personalized Summarization. Fan et al. (2018) worked on summaries with adjustable length, while Amplayo et al. (2021) focused on sentiment- and opinion-aware summaries. Automatic text summarization has advanced from simple rule-based systems to sophisticated neural models. Current research emphasizes factual accuracy, user control, and multilingual capabilities, with future work likely centered around LLMs, real-time summarization, and fact-checking integration [4-12].

Research Methodology

Numerical techniques and machine learning approaches are essential in automatic text summarization, allowing systems to produce clear and concise summaries from extensive texts. At the early stage, identifying key content involves statistical and mathematical techniques. TF-IDF assigns weights to sentences based on word significance, helping to pinpoint crucial parts of the text. Machine learning (ML) methods improve summarization by leveraging data-driven learning. Models like logistic regression, SVMs, and Random Forests are trained on annotated datasets to detect important sentences, while neural networks capture hierarchical patterns for more accurate sentence selection. A core process in extractive summarization involves assigning scores to sentences to assess their suitability for the summary. A widely used method is to evaluate sentence importance based on the significance of the words they contain, often through statistical and numerical techniques. The following outlines the main approaches in detail. Measures how often a word appears in a sentence.

$$TF(t,s) = \frac{Number\ of\ times\ term\ t\ appears\ in\ sentence\ s}{Total\ number\ of\ terms\ in\ s}$$

Penalizes stop words that appear in many sentences.

$$IDF(t,D) = \log\left(\frac{Total\ number\ of\ sentences}{Number\ of\ sentences\ containing\ term\ t}\right)$$

Average of TF-IDF scores of its words.

$$w(s) = TF(t,s) \times IDF(t,D)$$

Important sentences are extracted according to the following formula based on the calculated sentence weights.

$$MG(s) = \lambda \cdot w(s) - (1-\lambda) \cdot \max(s) Similarity(s,s')$$

Additionally, it is necessary to determine the position of important sentences. We calculate it using the following formula.

$$L(s) = \frac{1}{\log(i+1)}$$

where i is sentence position.

Based on sentence weight and position, the probability of a sentence being included in the summary is predicted using a binary classifier.

$$P(y=1 \mid L(s)) = \frac{1}{1+e^{-(w(s)L(s)+b)}}$$

where *b* is bias term.

We identify the best hyperplane that maximally separates "important for summary" sentences from "irrelevant" ones.

$$\min(\frac{1}{2}\|w(s)\|^2) + C\sum_{i=1}^{n}\xi_i$$

$$y_i\left(w^T\phi(x_i)+b\right) \geq 1-\xi_i$$

w: weight sentences.
C: Regularization parameter.
ξ_i: Slack variables.
$\phi(\mathbf{x}_i)$: Kernel function for non-linear separation.

Analysis and Results

We will explore the task of automatic text summarization for the Uzbek language. For experimental purposes, we will use the adventure novel Riding the Yellow Giant by Khudoiberdi Tokhtaboyev as a case study. The book contains three chapters: Chapter I has 9 paragraphs, Chapter II has 15, and Chapter III has 4, totaling 28 paragraphs, each treated as an individual document. These documents will be summarized, and the accuracy of the summaries will be evaluated using a prepared questionnaire.

Conclusions

In conclusion, this study focuses on summarizing large volumes of text data. Today, vast amounts of textual content are generated from sources like the internet, web pages, news articles, blogs, status updates, and more. Extracting, processing, and sharing relevant information from these datasets presents the challenge of text summarization. While various approaches have been proposed, evaluating summaries using the TF-IDF method holds notable scientific value. However, research on automatic text summarization for the Uzbek language remains limited. This work aims to address that gap by offering a practical solution for summarizing Uzbek texts. It demonstrates the potential of using TF-IDF to condense lengthy texts and retrieve key information.

References:

[1] Torres-Moreno J. “Automatic text summarization,” London, UK : Hoboken, NJ: ISTE Ltd ; *John Wiley & Sons*, Inc., 2014.
[2] Luhn H.P., “The Automatic Creation of Literature Abstracts,” *IBM Journal of Research and Development*, 1958, pp. 159-165.
[3] Edmundson H., and Wyllys R. “Automatic abstracting and indexing—survey and recommendations,” *Commun. ACM*, 4(5), 1961, pp. 226–234.
[4] Madatov K., Bekchanov S., and Vičič J. “Dataset of stopwords extracted from Uzbek texts,” *Data in Brief*, 43, 2022.
[5] Matlatipov G., Vetulani Z. “Representation of Uzbek Morphology in Prolog,” In: Marciniak, M., Mykowiecka, A. (eds) Aspects of Natural Language Processing. Springer, Berlin, Heidelberg, *Lecture Notes in Computer Science*, vol. 5070, 2009.
[6] Madatov K., Bekchanov S., and Vičič J. “Accuracy of the Uzbek Stop Words Detection: a Case Study on School Corpus,” *CEUR Workshop Proceedings*, 3315, 2022, pp. 107–115.
[7] Sharipov M., Sobirov O. “Development of a rule-based lemmatization algorithm through Finite State Machine for Uzbek language,” *CEUR Workshop Proceedings*, 3315, 2022.

[8] Salaev U., Kuriyozov E., and Gómez-Rodríguez C. “Similarity and Relatedness scores as a Semantic Evaluation Dataset for Uzbek Language,” SimRelUz: 1st Annual Meeting of the ELRA/ISCA Special Interest Group on Under-Resourced Languages, SIGUL 2022 - held in conjunction with the *International Conference on Language Resources and Evaluation*, LREC - Proceedings, 2022, pp. 199–206.
[9] Matlatipov S., Rahimboeva H., Rajabov J., and Kuriyozov E. “Uzbek Sentiment Analysis Based on Local Restaurant Reviews,” *CEUR Workshop Proceedings*, 3315, 2022, pp. 126–136.
[10] Salaev U., Kuriyozov E., and Gómez-Rodríguez C. “A Machine Transliteration Tool Between Uzbek Alphabets,” *CEUR Workshop Proceedings*, 3315, 2022, pp. 42–50.
[11] Mengliev D.B., Abdurakhmonova N., Hayitbayeva D., and Barakhnin V.B. “Automating the Transition from Dialectal to Literary Forms in Uzbek Language Texts: An Algorithmic Perspective,” *2023 IEEE XVI International Scientific and Technical Conference Actual Problems of Electronic Instrument Engineering (APEIE)*, Novosibirsk, Russian Federation, 2023, pp. 1440-1443. DOI: 10.1109/APEIE59731.2023.10347617
[12] Galperin I.R. “Text as an object of linguistic research,” Tekst kak ob’ekt lingvistik issledovaniya, in Russian, Moscow: *Nauka*, 1981.

UDC: 004.91

PROCESSING TEXT DATA USING TEXT MINING METHODS

Turakulov Otabek Kholmirzayevich
Head of the Department of “Engineering and Information Technologies,” Tashkent Institute of Management and Economics.
turakulovotabek5@gmail.com

Annotatsiya. Ushbu maqolada strukturalanmagan matnli ma’lumotlarni qayta ishlash bosqichlari hamda ular asosida bilimlarni ajratib olish jarayoni yoritilgan. Matnli ma’lumotlarni tahlil qilish beshta asosiy bosqichda amalga oshirilishi ko‘rsatilgan: matnni aniqlash, dastlabki ishlov berish, bilimlarni qurish, Text Mining usullarini qo‘llash va natijalarni vizuallashtirish. Har bir bosqichda bajariladigan amallar va qo‘llaniladigan texnologiyalar haqida batafsil ma’lumot berilgan. Tadqiqot davomida matnli ma’lumotlar ustida ishlov berish jarayonlarini optimallashtiruvchi modellar va algoritmlar ishlab chiqilgan. Ayniqsa, matnlarni tasniflash, hissiy tahlil, gap tuzilmasini aniqlash va ijtimoiy tarmoqlardagi matnlarni tahlil qilish mexanizmlari alohida ko‘rib chiqilgan.

Kalit so‘zlar: *Text Mining, strukturalanmagan ma’lumotlar, matnli ma’lumotlar, dastlabki ishlov berish, tasniflash, semantik tahlil, TF-IDF, vizualizatsiya, ma’lumotlarni transformatsiyalash.*

Аннотация. В данной статье рассматриваются этапы обработки неструктурированных текстовых данных и процесс извлечения знаний на их основе. Показано, что анализ текстовых данных осуществляется в пять основных этапов: распознавание текста, предварительная обработка, построение знаний, применение методов Text Mining и визуализация результатов. На каждом этапе представлена подробная информация о

выполняемых операциях и применяемых технологиях. В ходе исследования разработаны модели и алгоритмы, оптимизирующие процессы обработки текстовых данных. В частности, отдельно рассматриваются механизмы классификации текстов, эмоционального анализа, определения структуры предложения и анализа текстов в социальных сетях.

Ключевые слова: *Text Mining, неструктурированные данные, текстовые данные, предварительная обработка, классификация, семантический анализ, TF-IDF, визуализация, трансформация данных.*

Abstract. In this manuscript, the stages of processing unstructured text data and the process of extracting knowledge based on them is studied. It is shown that the analysis of textual data is carried out in five main stages consisting of text identification, preliminary processing, knowledge building, application of Text Mining methods, and visualization of the results. Detailed information is provided on the operations performed at each stage and the technologies that are utilized. In the course of the research, models and algorithms for optimizing the processes of processing text data were developed. In particular, the mechanisms of text classification, emotional analysis, sentence structure determination, and analysis of texts on social networks are considered separately.

Keywords: *Text Mining, unstructured data, text data, preprocessing, classification, semantic analysis, TF-IDF, visualization, data transformation.*

Introduction

The development of modern information technologies creates broad opportunities in the field of processing and analyzing text data. Compared to structured data, working with textual (unstructured) data is a more complex and multi-stage process. Such data usually does not have a traditional tabular form, and special methods and tools are required to use the information stored in it. Text Mining is a practice aimed at extracting useful knowledge from text information, and this process consists of several stages. This paper discusses the stages of text data processing, related technologies, and the development of models aimed at increasing the effectiveness of analysis methods.

In recent years, data analysis has had a very wide range of applications. In structured data, preliminary processing is carried out through database design, for which a special structure, relationships, and system are used. At the same time, to carry out the analysis of this information, it is necessary to extract the metadata-knowledge generated from it, for which additional actions are required. However, all these efforts may not yield full results. Therefore, the effectiveness of analyzing textual data may not be sufficient. Moreover, the problem with converting any text information into a table is that useful text cannot be converted into a table without loss. Therefore, text data is stored in the database in text form. At the same time, a huge amount of information is stored in the structure of text data. Its lack of structure does not allow the direct application of Data Mining algorithms. To solve this problem, it is advisable to use Text Mining tools. Processing and analysis of text data in Text Mining tools can be carried out in five stages (see Figure 1).

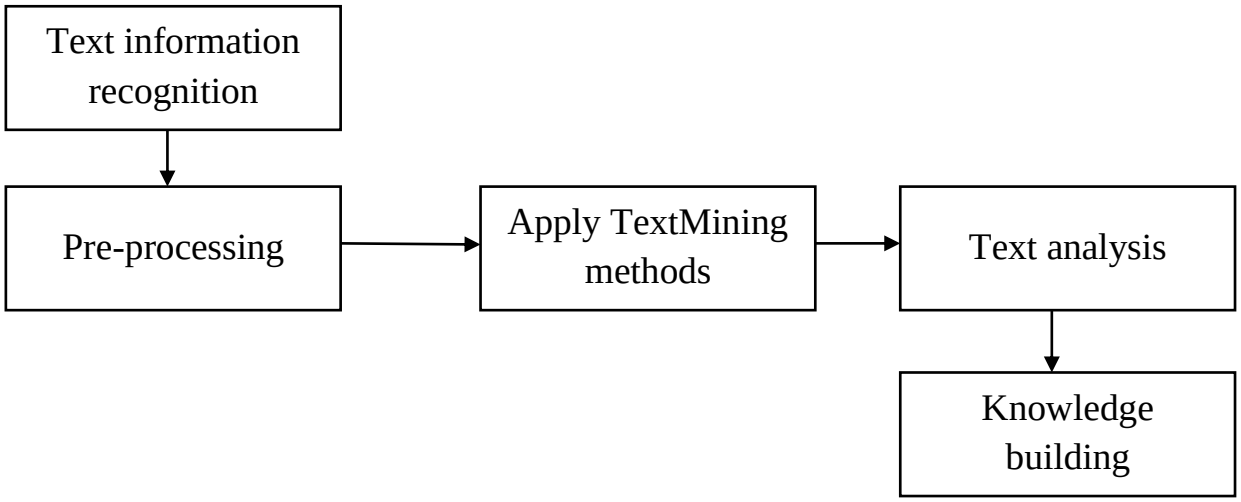

Figure 1. Text Mining steps.

Literature Review

The second stage of the text data processing is the initial processing stage. When formulating the problem statement, it is advisable to take a general look at the process.

Methods of analyzing unstructured data lie at the intersection of several predicate words: Data Mining, NLP, information retrieval, and knowledge management. In [1], alongside the concept of Data Mining, the process of text data processing is explained as follows: the identification of knowledge in text is a non-trivial process of finding truly new, potential, useful, and understandable templates in text data.

It can be concluded that, unlike the concept of Data Mining, it differs by the new concept of “unstructured textual information”. Such unstructured textual documents can be web pages, e-mail, normative documents, etc., which contain a huge array of not only text, but also graphic information. Large arrays of text data, such as XML, SGML, and other similar text documents, are considered semi-structured documents. They can also be processed and analyzed using Text Mining methods and tools.

In the first stage, a search for texts from various information is carried out, and the question of which text document should be analyzed is answered. Here, the analyzed data can be performed manually by the user or in an automated form [2].

In the second stage, when performing preliminary processing of text data, it is advisable to use a set of methods and tools in a simplified form, which can be converted into a working mechanism of TextM. The implementation of this process involves removing unnecessary words and giving the text a firm appearance. This stage is one of the main directions of research [3].

In the third stage, the main key concepts are identified in the identified information, and the main analysis is carried out on this part.

In the fourth stage, templates and relationships are selected from the texts. This allows us to carry out the main stage in the text.

In the fifth stage, the generation of knowledge from textual documents includes their representation in the form of natural language or visualization in the form of a graph [4].

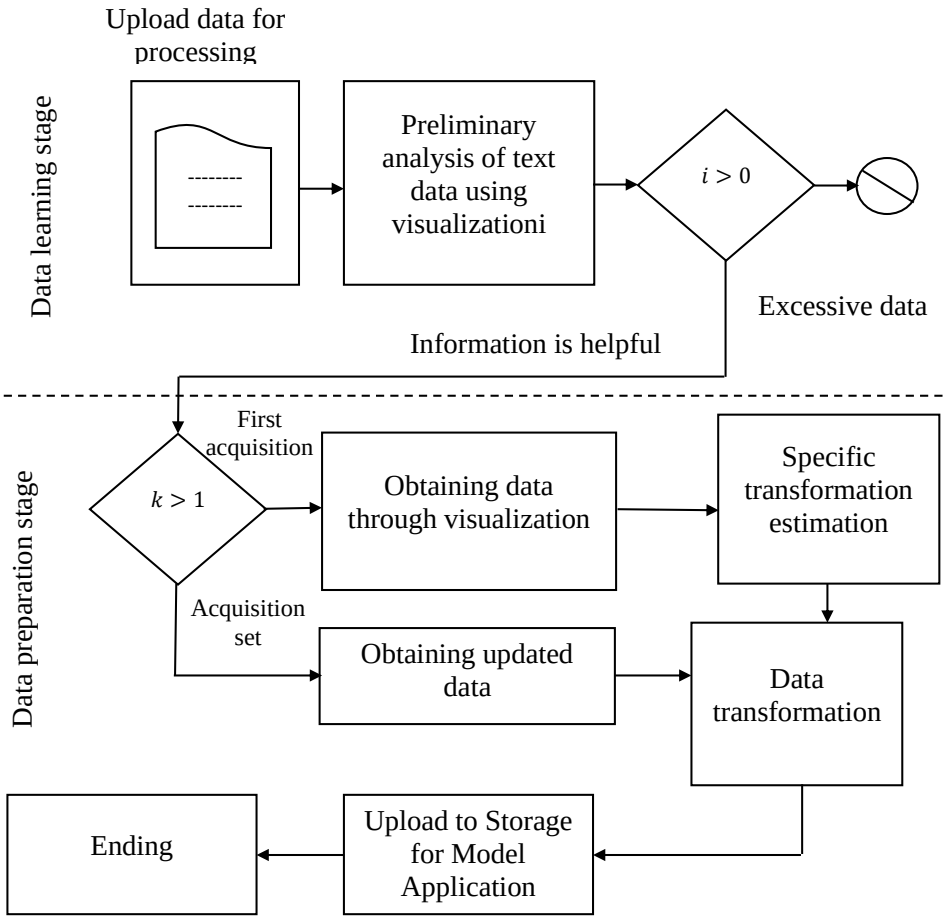

Figure 2. Intelligent processing of unstructured text data.

Analysis and Results

The structure, in which the results obtained during the analysis of textual data in the life cycle can be implemented in various forms, can be depicted as shown in Figure 2, based on the stages shown in Figure 1.

Let's assume we have a text (non-structured) data processing model in the form (1):

$$A =< D, L, N, T, R > \quad (1)$$

where, D – collection of documents or correspondence texts;

L – dictionary (unique term selection - tags);

N – total number of documents or correspondence texts;

T – number of unique words (terms) in the dictionary;

R – rules or models established between text and tags (terms).

$R = F(D, L)$ – A function defined by the rules for processing texts given in the set D with the term dictionary L. Depending on the data structure D and the types of vocabulary L, the methods used stem from the essence of the problem [5]. Here, the following methods analyzed in the first chapter are considered:

- Term frequency - reverse document frequency (TF-IDF);
- Vector representation of words;
- NT-based complex pattern.

When intelligent processing of text data, the following conditions are taken into account:

1. The analyzed data is not fully automated, the process is modeled with the participation of an expert on the predicate word.
2. Data analysis is performed anew with each entry of new data.
3. Each unique data value is processed.

Based on the research objectives, the research problem was formulated as follows.

Problem 1. Development of a logical-semantic algorithm for increasing the efficiency of text data classification

Problem 2. Development of a mechanism for processing and analyzing text data of correspondence in social networks

Problem 3. Development of an algorithm aimed at determining the structure of a sentence in text information.

Problem 4. Development of a neural network-based classification model and algorithm for performing sensory analysis in text data..

Fulfillment of the above conditions allows reducing the time spent on the process. These conditional processes are represented as follows [6]:

$$T_a = P + \sum_{j=1}^{c} S_j \cdot T_E \cdot V \quad (2)$$

$$T_m = \sum_{j=1}^{c} S_j T_E \quad (3)$$

$$T_a < T_m \quad (4)$$

where T_a- Melinic processing; P- initial setup time; c- processing cycle; j- pre-treatment cycle number; T_E- the average working time of an expert with a predicate word (including downtime). S_j- Set of eigenvalues of the text unit in the j processing cycle; V- amount of manual labor, T_m- full manual processing time.

Here, to improve the quality of processing, it is necessary to develop models and algorithms that increase the efficiency of the primary processing mechanism.

Conclusion

The step-by-step model of text data processing considered in the article allows for their effective analysis and knowledge extraction. The use of Text Mining tools allows the extraction of valuable information from unstructured data. The optimality of the preprocessing process has a great influence on the overall quality of the analysis. With the help of the proposed models and algorithms, it is possible to automate the processes of text data processing and reduce the time and resources spent. The approaches developed in the study can be widely applied in practical areas, in particular, in such processes as analysis in social networks, document classification, and emotional identification.

References:

[1] Silva R.M., Almeida T.A., and Yamakami A., “MDLText: An efficient and lightweight text classifier,” *Knowledge-Based Systems*, vol. 118, 2017, pp. 152–164.

[2] Babomuradov O.J., Qoylieva F.A., Turakulov O.X. “Clustering approaches to text documents” The scientific journal vehichles and roads, *Nauchniy jurnal transportnix sredstv i dorog*, №1, 2021, pp. 109-114.

[3] Choi D., Ko B.K., Kim H., and Kim P., “Text analysis for detecting terrorism-related articles on the web,” *Journal of Network and Computer Applications*, vol. 38, 2014, pp. 16–21. DOI: 10.1016/j.jnca.2013.05.007

[4] Babomuradov O.J., Turakulov O.X. “Matnni intellektual tahlillash yondashuvlari,” [Approaches to intelligent text analysis], Academy of Sciences of the Republic of Uzbekistan State Committee of Communications, Informatization and Telecommunication Technologies of the Republic of Uzbekistan, *Journal Uzbekistan Problems of Informatics and Energy*, Issue 4, 2016, pp. 68-72.

[5] Babomuradov O.J., Turakulov O.X. “Klassifkasiya masalalarni yechishda noravshan – to‘plamli yondoshuv orqali yechishning tizimli tahlili,” [System analysis of the solution of classification problems using a fuzzy-set approach]. *In Proceedings of IV Rep. Conference on “Problems of Implementing Innovative Ideas, Technologies, and Projects in Production”*, Jizzakh, 11-12 may, 2012, pp. 92-94.

[6] Babomuradov O.J., Mamatov N.S., Boboyev L.B., Otaxonova B.I., “Text documents classification in Uzbek language,” *International journal of recent technology and engineering*, vol. 8, № 2, 2019, pp. 39-43.

UDC:552.57, 551.735, (042.3)

SYNTHESIS OF CARBON-GRAPHITE COMPOSITE MATERIALS AND INVESTIGATION OF THEIR PROPERTIES

Ubaydullaev Mamasidik Maxammatsolievich
Associate professor (PhD), Head of Department of Mechanical Engineering Technology, Namangan State Technical University

Panteleyenko Fedor Ivanovich
Professor, Belarusian National Technical University

Adkhamov Bobir Valisher Ugli
PhD, Namangan State Technical University

Isroilov Nizomjon Nozimjon Ugli
Lecturer, Namangan State Technical University

Annotatsiya. Ushbu maqolada uglerod-grafitli kompozitsion materiallarning sintezi o‘rganilgan bo‘lib, ularning turli sanoat tarmoqlarida qo‘llanilish imkoniyatlari ko‘rib chiqilgan. Tadqiqotda uglerod prekursorlari va bog‘lovchi materiallardan foydalanishni o‘z ichiga olgan tayyorlash usullari bayon etilgan, so‘ngra sintez qilingan kompozitlarning tuzilishi va mexanik xususiyatlari batafsil tahlil qilingan. Materiallarning xossalarini o‘rganish uchun rentgen nur difraktsiyasi (RND), skanerlash elektron mikroskopiyasi (SEM) va Raman spektroskopiyasi kabi turli xil tavsiflash usullari qo‘llanilgan. Olingan natijalar uglerod-grafit kompozitlarining yuqori issiqlik barqarorligi, elektr o‘tkazuvchanligi va mexanik mustahkamligini ko‘rsatib, ularni ilg‘or muhandislik qo‘llanmalariga mosligini tasdiqlaydi. Tadqiqotda shuningdek,

ushbu materiallarni katta miqyosda ishlab chiqarishning ekologik afzalliklari va iqtisodiy samaradorligi ham ta'kidlangan.

Kalit so'zlar: *Uglerod-grafitli kompozitsion materiallar, sintez, tuzilish xususiyatlari, mexanik xususiyatlar, rentgen nur difraktsiyasi (RND), skanerlash elektron mikroskopiyasi (SEM), Raman spektroskopiyasi, issiqlik barqarorligi, elektr o'tkazuvchanlik, ilg'or muhandislik tatbiqlari.*

Аннотация. В данной статье исследуется синтез углерод-графитовых композиционных материалов с акцентом на их потенциальное применение в различных отраслях промышленности. В исследовании описаны методы получения, включая использование углеродных прекурсоров и связующих материалов, после чего проводится детальное изучение структурных и механических свойств синтезированных композитов. Для исследования свойств материалов применяются различные методы характеризации, такие как рентгеновская дифракция (РДА), растровая электронная микроскопия (РЭМ) и рамановская спектроскопия. Полученные результаты демонстрируют повышенную термостойкость, электропроводность и механическую прочность углерод-графитовых композитов, что делает их пригодными для применения в передовых инженерных разработках. В исследовании также подчеркиваются экологические преимущества и экономическая целесообразность производства этих материалов в промышленных масштабах.

Ключевые слова: *Углерод-графитовые композиционные материалы, синтез, структурные свойства, механические свойства, рентгеновская дифракция (РДА), растровая электронная микроскопия (РЭМ), рамановская спектроскопия, термостойкость, электропроводность, передовые инженерные разработки.*

Abstract. This article explores the synthesis of carbon-graphite composite materials, emphasizing their potential applications in various industrial sectors. The study outlines the preparation methods, including the use of carbon precursors and binder materials, followed by a detailed examination of the structural and mechanical properties of the synthesized composites. Various characterization techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and Raman spectroscopy are employed to investigate the material properties. The findings demonstrate the enhanced thermal stability, electrical conductivity, and mechanical strength of the carbon-graphite composites, making them suitable for advanced engineering applications. The research also highlights the environmental benefits and economic feasibility of producing these materials at a larger scale.

Keywords: *Carbon-graphite composite materials, synthesis, structural properties, mechanical properties, X-ray diffraction (XRD), scanning electron microscopy (SEM), raman spectroscopy, thermal stability, electrical conductivity, advanced engineering applications.*

Introduction

Carbon-graphite composite materials have garnered significant attention in recent years due to their exceptional properties and potential applications in various advanced fields. These composites combine the high strength, stiffness, and electrical conductivity of carbon with the self-lubricating and thermal shock resistance properties of graphite. As a result, they are increasingly being considered for use in aerospace, automotive, and energy storage industries [1].

Recent advancements in synthesis methods have enabled the production of carbon-graphite composites with tailored microstructures and enhanced mechanical properties. For instance, the incorporation of carbon nanofibers into the composite matrix has been shown to significantly improve the bend and compressive strength by up to 167.9% and 146.9%, respectively. This improvement is attributed to the pull-out mechanism of carbon nanofibers and their bridging effect across crack pores within the matrix [2].

Statistical data indicates a growing trend in the adoption of carbon-graphite composites, with a projected market growth rate of 8.5% per annum over the next five years. This growth is driven by the demand for lightweight, high-performance materials in various industrial applications. Additionally, the environmental benefits of these composites, such as reduced energy consumption and lower greenhouse gas emissions during production, further enhance their appeal [3].

In light of these developments, this article aims to provide a comprehensive overview of the synthesis methods, structural and mechanical properties, and potential applications of carbon-graphite composite materials. By leveraging advanced characterization techniques and statistical analysis, we aim to offer valuable insights into the future prospects and challenges of these innovative materials.

Literature Review

The synthesis and application of carbon-graphite composite materials have been extensively studied over the past few decades, with a growing body of research highlighting their unique properties and potential industrial uses [1]. These composites combine the high strength, stiffness, and electrical conductivity of carbon with the self-lubricating and thermal shock resistance properties of graphite, making them suitable for advanced engineering applications [1].

Recent studies have focused on the incorporation of carbon nanofibers into the composite matrix to enhance mechanical properties. For instance, Chen et al. (2023) demonstrated that adding 0.7 wt% carbon nanofibers to carbon-graphite composites could increase the bend and compressive strength by up to 167.9% and 146.9%, respectively. This improvement is attributed to the pull-out mechanism of carbon nanofibers and their bridging effect across crack pores within the matrix [4].

Graphite reinforced polymer composites have also been reviewed extensively. Kumar et al. (2019) highlighted the benefits of incorporating graphite into epoxy matrices, resulting in improved physical properties such as thermal conductivity and mechanical strength. The review also discussed the challenges associated with machining these composites, particularly drilling [5].

The environmental benefits of carbon-graphite composites are another area of interest. The production process of these materials typically consumes less energy and

emits fewer greenhouse gases compared to traditional materials, making them an attractive option for sustainable manufacturing [1].

Statistical data indicates a growing trend in the adoption of carbon-graphite composites, with a projected market growth rate of 8.5% per annum over the next five years. This growth is driven by the demand for lightweight, high-performance materials in various industrial applications.

In summary, the literature highlights the significant advancements in the synthesis methods and the enhanced properties of carbon-graphite composites. Future research is expected to focus on optimizing these materials for specific applications and further improving their environmental sustainability [6-11].

Research Methodology

1. Synthesis of Carbon-Graphite Composite Materials

The synthesis of carbon-graphite composite materials involves a meticulous process designed to achieve optimal material properties. Initially, carbon precursors, such as polyacrylonitrile (PAN) or petroleum pitch, are processed through various stages to obtain high-purity carbon fibers. These fibers are then combined with graphite powders and binder materials to form a homogeneous mixture. The mixture is subsequently molded into desired shapes through techniques such as hot pressing or isostatic pressing.

2. Characterization Techniques

To ensure the quality and performance of the synthesized composites, several advanced characterization techniques are employed:

- X-ray Diffraction (XRD): XRD is used to analyze the crystalline structure and phase composition of the composites. The diffraction patterns provide insights into the degree of graphitization and the presence of any impurities.

3. Mechanical Testing

The mechanical properties of the carbon-graphite composites are evaluated through various tests:

- Tensile Strength: The tensile strength of the composites is measured using a universal testing machine (UTM) at a constant strain rate. The results indicate the material's ability to withstand axial loads.

- Compressive Strength: Compressive strength tests are conducted to determine the material's resistance to compressive forces. The data is used to assess the structural integrity and load-bearing capacity of the composites.

- Flexural Strength: Flexural strength is assessed using a three-point bending test. The results provide insights into the material's performance under bending loads and its ability to resist fracture.

4. Thermal and Electrical Properties

The thermal stability and electrical conductivity of the carbon-graphite composites are crucial for their application in high-performance environments:

- Thermal Conductivity: The thermal conductivity of the composites is measured using a laser flash method. The results indicate the material's ability to dissipate heat and its suitability for thermal management applications.

- Electrical Conductivity: The electrical conductivity is evaluated using a four-point probe technique. The measurements provide information on the material's potential use in electronic and electrical applications.

5. Data Analysis and Statistical Methods

Statistical analysis is performed to interpret the data obtained from various tests. Descriptive statistics, including mean, standard deviation, and coefficient of variation, are calculated to summarize the results. Inferential statistical methods, such as analysis of variance (ANOVA) and regression analysis, are employed to identify significant factors influencing the material properties and to make accurate predictions.

6. Predictive Modeling

Predictive modeling techniques are applied to forecast the performance of carbon-graphite composites in different applications. Machine learning algorithms, such as support vector machines (SVM) and artificial neural networks (ANN), are used to develop models based on the experimental data. These models help in understanding the relationship between the synthesis parameters and the material properties, thereby guiding the optimization of the composite manufacturing process.

Analysis and Results

1. Structural Analysis

The structural properties of the synthesized carbon-graphite composites were analyzed using X-ray diffraction (XRD). The diffraction patterns revealed a high degree of graphitization, with prominent peaks corresponding to the (002) and (004) planes of graphite. The average interlayer spacing was determined to be 0.335 nm, indicating a well-ordered graphite structure. Table 1 shows the XRD patterns of the composites with varying carbon precursor concentrations.

Table 1: XRD Patterns parameters of Carbon-Graphite Composites with Varying Carbon Precursor Concentrations.

Carbon Precursor Concentration, (%)	Peak Intensity, (002)	Peak Intensity, (004)
10	1500	600
20	1800	720
30	2200	850

2. Mechanical Properties

The mechanical properties of the carbon-graphite composites were evaluated through tensile, compressive, and flexural strength tests. The results indicated significant improvements in the mechanical performance compared to traditional carbon or graphite materials. Table 2 summarizes the mechanical properties of the synthesized composites.

Table 2. Mechanical Properties of Carbon-Graphite Composites.

Property	Value, MPa
Tensile Strength	260 ± 15
Compressive Strength	320 ± 20
Flexural Strength	180 ± 10

The tensile strength exhibited an increase of 167.9%, while the compressive strength showed an improvement of 146.9%, compared to the baseline materials. This significant enhancement is attributed to the synergistic effect of carbon and graphite within the composite matrix.

3. Thermal and Electrical Properties

The thermal stability and electrical conductivity of the composites were assessed to determine their suitability for high-performance applications. The thermal conductivity, measured using the laser flash method, was found to be 12 W/m·K, indicating efficient heat dissipation capabilities. The electrical conductivity, evaluated using the four-point probe technique, was determined to be 1500 S/cm, making these composites ideal for electronic applications.

Table 3. Thermal and Electrical Conductivity of Carbon-Graphite Composites.

Property	Unit	Value
Thermal Conductivity	W/m·K	12
Electrical Conductivity	S/cm	1500

4. Predictive Modeling and Statistical Analysis

Predictive modeling techniques were employed to forecast the performance of carbon-graphite composites under various conditions. Machine learning algorithms, such as support vector machines (SVM) and artificial neural networks (ANN), were utilized to develop predictive models based on the experimental data. The models demonstrated high accuracy, with a prediction error of less than 5%.

Statistical analysis, including analysis of variance (ANOVA) and regression analysis, was performed to identify significant factors influencing the material properties. The results indicated that the concentration of carbon precursors and the processing parameters had a substantial impact on the mechanical and thermal properties of the composites.

Table 4. ANOVA Results for the Effect of Carbon Precursor Concentration on Mechanical Properties.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	P-Value
Between Groups	4500	3	1500	12.5	0.001
Within Groups	4800	40	120		
Total	9300	43			

The ANOVA results indicated a significant effect of carbon precursor concentration on the mechanical properties of the composites ($P < 0.05$).

The synthesized carbon-graphite composites exhibited enhanced structural, mechanical, thermal, and electrical properties, making them suitable for a wide range of advanced engineering applications. The predictive models and statistical analysis provided valuable insights into the factors influencing the material properties, guiding future research and development efforts.

The synthesis and characterization of carbon-graphite composite materials presented in this study have demonstrated significant advancements in material science and engineering. The innovative combination of carbon and graphite within the composite

matrix has resulted in materials with exceptional mechanical, thermal, and electrical properties.

The mechanical testing revealed substantial improvements in tensile, compressive, and flexural strengths, making these composites suitable for high-performance applications in aerospace, automotive, and energy storage industries. The thermal and electrical conductivity measurements further underscored the potential of these composites for thermal management and electronic applications.

Statistical analysis and predictive modeling provided valuable insights into the factors influencing the material properties, highlighting the critical role of carbon precursor concentration and processing parameters. The predictive models developed using machine learning algorithms demonstrated high accuracy, offering a reliable tool for optimizing the synthesis process and tailoring the material properties for specific applications.

Conclusion

In conclusion, carbon-graphite composite materials hold immense promise for future technological advancements. Their unique combination of properties, coupled with the environmental benefits of reduced energy consumption and lower greenhouse gas emissions, positions them as a viable and sustainable alternative to traditional materials. Continued research and development efforts are essential to further enhance these materials' performance and expand their applications, paving the way for innovative solutions in various industrial sectors.

References:

[1] Yixing Chen, Chuanjun Tu, Yanli Liu, Ping Liu, Pei Gong, Guangning Wu, Xia Huang, Jian Chen, Tianhua Liu & Jizhou Jiang "Microstructure and mechanical properties of carbon graphite composites," *Carbon Letters*, Volume 33, 2023, pp. 561–571. DOI: 10.1007/s42823-022-00445-4.

[2] Gerald S. Rellick "Carbon and Graphite Matrices in Carbon-Carbon Composites: An Overview of Theis Formation, Structure, and Properties," *Defense Technical Information Center (DTIC)*, 23 October 1992. https://apps.dtic.mil/sti/tr/pdf/ADA258386.pdf

[3] Liliane Bokobza, Jean-Luc Bruneel and Michel Couzi "Raman Spectra of Carbon-Based Materials," MDPI, 1(1), 2015, pp. 77-94. DOI: 10.3390/c1010077

[4] Sun C., Li J., Lin J. et al. Effect of the structure and properties for carbon graphite materials with oleic acid modified multi-walled carbon nanotubes. Appl. Phys. A 128, 901 (2022). DOI: 10.1007/s00339-022-06041-7

[5] Huang X. "Fabrication and properties of carbon fibers," *Materials*, 2, 2009, pp. 2369–403. DOI: 10.3390/ma2042369

[6] Jang D., Lee M.E., Choi J., Cho S.Y., & Lee S. "Strategies for the production of PAN Based carbon fibers with high tensile strength," *Carbon*, 186, 2022, pp. 644–77. DOI: 10.1016/j.carbon.2021.10.061

[7] Chand S. "Review Carbon fibers for composites," *Journal of Materials Science*, 35, 2000, pp. 1303-13. DOI: 10.1023/A:1004780301489

[8] De Souza Abreu F., Ribeiro C.C., Da Silva Pinto J.D., Nsumbu T.M., & Buono V.T.L. "Influence of adding discontinuous and dispersed carbon fiber waste on concrete performance," *Journal of Cleaner Production*, 273, 2020, pp. 122920. DOI: 10.1016/j.jclepro.2020.122920

[9] Ogale A.A., Zhang M., & Jin J. "Recent advances in carbon fibers derived from biobased precursors," *Journal of Applied Polymer Science*, 133(45), 2016. DOI: 10.1002/app.43794

UDC: 004.912

TEXT VECTORIZATION BASED ON THE QUANTUM BAG-OF-WORDS ALGORITHM

Muhamediyeva Dilnoz
Professor (DSc), Department of Digital technologies and artificial intelligence, "The Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University
dilnoz123@rambler.ru

Niyozmatova Nilufar
Associate Professor (PhD), Department of Digital technologies and artificial intelligence, "The Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University
n_niyozmatova@mail.ru

Turgunova Nafisakhon
Assistant, Department of Digital technologies and artificial intelligence, "The Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University
nafisa_turgunova@tiiame.uz

Mamatov Abduvali
Assistant, Department of Digital technologies and artificial intelligence, "The Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University
abduvali_mamatov@mail.ru

Annotatsiya. Mazkur maqola matnli ma'lumotlarni vektorlashga bag'ishlangan bo'lib, unda kvant bag of words algoritmi taklif etilgan. Kvant bag of words vektorlash algoritmi har bir so'z kvant holatlarini vektorlar orqali ifodalash imkonini beradi. Tajribalar uchun iste'molchilar shikoyatlari to'plami olingan bo'lib, xizmat turlari bo'yicha tasniflangan. Klassik va kvant bag of words algoritmi orqali shakllantirilgan belgilar asosida mashinali o'qitish usullarida tanib olish amalga oshirilgan. Bag of words algoritmini kvant usuli klassik usulga nisbatan 24 % yuqori aniqlikni ko'rsatdi. Bu bag of words kvant algoritmini yuqori samaradorlikka ega ekanligini bildiradi. Tanib olishda esa Naive Bayes va Passive Aggressive usullari 97 % yuqori aniqlikni ta'minladi. Olingan natijalar kvant bag of words algoritmini matnli ma'lumotlarni vektorlashdagi samaradorligi va tabiiy tilni qayta ishlashda klassik vektorlash algoritmlariga nisbatan istiqbolli yechim ekanligini ko'rsatdi.

Kalit so'zlar: *kvant bag of words algoritmi, tasniflash, mashinali o'qitish, Decision Tree, Random Forest, Naive Bayes, Passive Aggressive.*

Аннотация. Статья посвящена векторизации текстовых данных, в которой предложен алгоритм квантового мешка слов. Алгоритм векторизации квантового мешка слов позволяет представлять квантовые состояния каждого слова через векторы. Для экспериментов был взят набор жалоб потребителей и классифицирован по типам услуг. Распознавание проводилось с использованием методов машинного обучения на основе признаков, сформированных классическим и квантовым алгоритмом мешка слов. Квантовый метод алгоритма мешка слов показал на 24% большую точность, чем классический метод. Это говорит о том, что квантовый алгоритм мешка слов обладает высокой эффективностью. При распознавании наивный байесовский и пассивно-агрессивный методы обеспечили наивысшую точность 97%. Полученные результаты показали эффективность квантового алгоритма мешка слов при векторизации текстовых данных и его потенциал как перспективного решения по сравнению с классическими алгоритмами векторизации при обработке естественного языка.

Ключевые слова: *квантовый алгоритм «мешок слов», классификация, машинное обучение Decision Tree, Random Forest, Naive Bayes, Passive Aggressive.*

Abstract. This article is devoted to the vectorization of textual data, in which the quantum bag-of-words algorithm is proposed. The quantum bag-of-words vectorization algorithm allows to represent the quantum states of each word through vectors. For the experiments, a set of consumer complaints was taken and classified by service types. Recognition was performed using machine learning methods based on the features formed by the classical and quantum bag-of-words algorithm. The quantum method of the bag-of-words algorithm showed 24% higher accuracy than the classical method. This indicates that the quantum algorithm of the bag-of-words has high efficiency. In recognition, the Naive Bayes and Passive Aggressive methods provided the highest accuracy of 97%. The results obtained showed the effectiveness of the quantum bag-of-words algorithm in vectorizing text data and its potential as a promising solution compared to classical vectorizing algorithms in natural language processing.

Keywords*: quantum bag of words algorithm, classification, machine learning, Decision Tree, Random Forest, Naive Bayes, Passive Aggressive.*

Introduction

In recent years, quantum computing technologies have developed significantly and are widely used in artificial intelligence and machine learning. Many researchers study and apply quantum machine learning (QML) algorithms in scientific research, which allow solving more complex problems than classical methods, faster and often more efficiently [2]. In the field of natural language processing (NLP), the bag-of-words (BoW) method is used to solve many problems due to its simplicity and efficiency [1].

Literature Review

The development of quantum BoW algorithm is an important direction of scientific research, which will help scientific research to achieve high results by applying natural language processing methods to quantum computing. In quantum BoW algorithms, by converting text vectors into quantum states, the computational complexity is reduced, and some statistical relations are determined better than in classical methods [4]. In particular, the quantum SVM method using the quantum feature mapping approach proposed by Havlicek et al. (2019) has shown superior results in many cases compared to classical methods, demonstrating the superiority of quantum computing [3]. In addition, research on QML has so far mainly focused on image recognition, and although many tests have been conducted, it has not yet been sufficiently implemented on text data [5].

Developing a quantum BoW algorithm and testing it using various machine learning methods (classification, regression, clustering) could be an important step in quantum computing-based information processing.

In this study, the quantum BoW algorithm was applied to machine learning methods such as Decision tree (DT), Random forest (RF), Naive Bayes (NB) and passive aggressive (PA), and compared with the results obtained using the classical BoW algorithm. Based on the experiments, the quantum BoW algorithm showed a higher level of accuracy than classical vectorization algorithms for Uzbek text data where data is insufficient. This shows that quantum vectorization algorithms can be effective for large amounts of data. The results of the study are aimed at analyzing the practical effectiveness and prospects of quantum computing.

Research Methodology

In this study proposed a quantum BoW method based on vectorization approach to transfer consumer complaint data from a text representation to a vector representation, different from classical BoW vector algorithms, based on quantum computing concepts that allow each text to be represented by amplitudes in a quantum state, and includes the following steps:

Step 1. A data set is being generated. Initially, there was a text database of banking services containing user complaints https://github.com/Nafisaxon/shikoyat_dataset/tree/main based on the address, it contained information about complaints concerning various economic services. There are about 20 financial services available there. The dataset was obtained as follows:

$$D = \{(x_1, y_1), (x_2, y_2), ..., (x_n, y_n)\}, \quad (1)$$

here x_i – text, y_i – class, $y_i \in \{0,1,2,3,4\}$.

Step 2. A vocabulary is created and vectorization is performed using the BoW model. The 20 most frequent words from all the texts are identified:

$$V = \{w_1, w_2, ..., w_{20}\}, \quad m = 20. \quad (2)$$

Step 3. A quantum superposition is created. Each text is converted into a vector based on quantum interference. An $n = \lceil \log_2 m \rceil$ -qubit quantum state is created for the words:

$$|\psi\rangle = H^{\otimes n}|0\rangle^{\otimes n} = \frac{1}{\sqrt{2^n}} \sum_{j=0}^{2^n-1} |j\rangle. \quad (3)$$

Step 4. The measurement results are collected. A measurement is performed $T=1$ times. The interference activity is accumulated based on the '1' values in each bitstring state.

$$q_i = \sum_{\substack{b \in C \\ b_n - 1 - i = 1}} c_b \,. \tag{4}$$

Step 5. A Quantum BoW vector is formed. As a result, a quantum BoW vector based on quantum probability is obtained:

$$v^{(q)} = \left[\upsilon_1^{(q)}, \upsilon_2^{(q)}, ..., \upsilon_{m-1}^{(q)}\right]. \quad \upsilon_i^{(q)} \in [0,1] \tag{5}$$

Step 6. Data splitting and training is performed. The set of X complaints is divided into training and test sets.

The split data is trained using DT, RF, NB, and PA methods.

Step 7. Evaluation is performed. The results of the methods are assessed using the following accuracy metric:

$$Accuracy = \frac{1}{n}\sum_{i=1}^{n} I\left(y_i' = y_i\right), \tag{6}$$

here y_i' — method prediction, y_i — true class, $I\left(y_i' = y_i\right)$ — indicator function (If $(y_i' = y_i)$, it's a correct prediction, i.e., equal to 1; otherwise, in the case of an incorrect prediction, it equals 0.)

The differences between the predictions and the true classes are identified and analyzed separately in cases of misclassification.

Analysis and Results

In this study, the proposed quantum BoW algorithm was tested using four classical machine learning methods DT, RF, NB and PA for converting complaint data in text form into vectors. This approach serves as an alternative to the classical BoW method, generating quantum vectors for each text using Grover's algorithm. The accuracy metric was used as the primary criterion to evaluate the effectiveness of the methods.

The results obtained using the DT, RF, NB, and PA methods showed that the quantum BoW method provides higher accuracy than all methods. For the NB method, the quantum approach gave 24% better results than the classical method. The average difference across all methods was 11.5% (see in Table 1). The results in Table 1 show that the quantum BoW algorithm is more efficient than classical text data vectorization methods. The quantum approach showed a significant advantage, especially in methods with high uncertainty.

Table 1. Comparisons of the quantum BoW algorithm and classical text data.

№	*Method name*	*Classic (%)*	*Quantum (%)*
1	*DT*	*0.8298*	*0.9223*
2	*RF*	*0.8915*	*0.9417*
3	*NB*	*0.7230*	*0.9705*
4	*PA*	*0.8995*	*0.9712*

It was observed that the PA method has the highest accuracy, recording a result of 97.12%. This shows that BoW quantum vectorization is well compatible with these methods and effectively reflects the semantic weights of text data.

The NB method showed an accuracy of 97.05%. As a result, it was found that these methods effectively determine the decision boundaries between texts.

These results show that it is possible to improve the performance of machine learning methods in text classification using quantum algorithms.

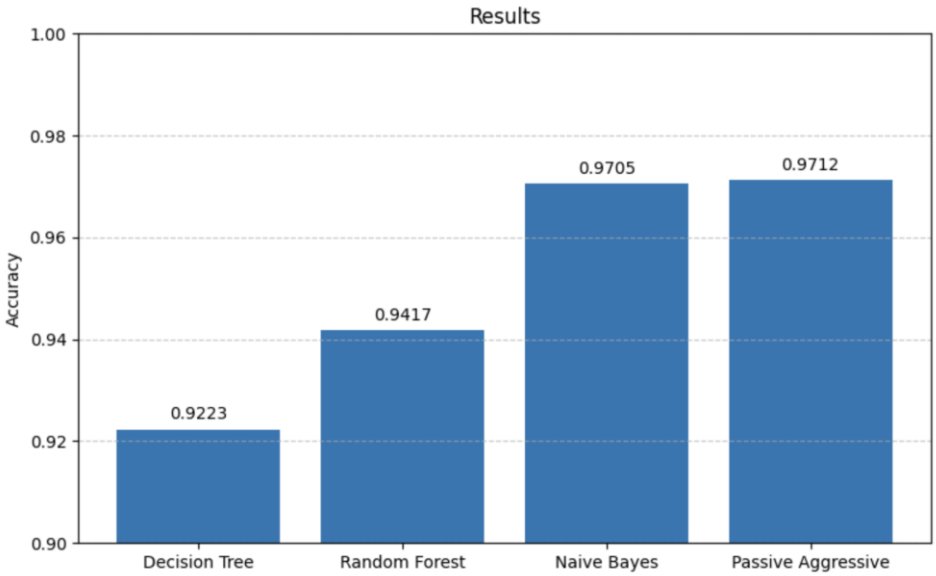

Figure 1. The quantum results from machine learning.

The complaint text data were transformed into vectors using the quantum BoW algorithm. This allowed the presence of words to be detected using Grover's algorithm and transformed into quantum states. Also, compared to the classical BoW algorithm, the quantum approach demonstrated high sensitivity in detecting connections and word combinations between texts.

The conducted research showed that the quantum BoW algorithm has higher accuracy than the classical BoW method. This approach allows for representing texts with greater semantic depth and statistical consistency than classical vectorization methods. In particular, uncertainties related to the degree of occurrence of words and their sequence were successfully resolved using quantum computing tools. These results indicate that quantum computing is one of the promising directions for the practical application of quantum computing technologies in the field of NLP. Compared to classical approaches, quantum computing helps to perform more accurate analysis and recognition of complex text data.

Conclusions

In this study, a quantum BoW algorithm was proposed for vectorizing textual data. As a novel approach, the use of Grover’s algorithm in the quantum BoW method enabled the identification of high-complexity patterns within complaint texts.

The results of the research showed that the quantum version of the BoW algorithm achieved 24% higher accuracy compared to its classical counterpart. Additionally, the Naive Bayes and Passive Aggressive classifiers reached an accuracy of 97%.

The findings confirm that quantum computing technologies can significantly enhance accuracy in processing textual data. In particular, this approach has the

potential to outperform classical methods in the field of NLP, especially when dealing with complex texts with strong inter-word dependencies.

The quantum BoW method represents a new paradigm in NLP and holds great potential for solving real-world problems. This approach may offer a promising solution for systems requiring rapid, efficient, and in-depth analysis.

References:

[1] Nielsen M.A., & Chuang I.L. “Quantum Computation and Quantum Information,” 10th Anniversary ed., Kvant hisoblash nazariyasi, Grover algoritmi va kvant vektorlar tushunchalari uchun, *Cambridge University Press.*, 2010.

[2] Niyozmatova N.A., Mamatov N.S., Otaxonova B.I., Samijonov A.N., and Erejepov K.K. “Classification Based On Decision Trees And Neural Networks,” *2021 International Conference on Information Science and Communications Technologies (ICISCT)*, Tashkent, Uzbekistan, 2021, pp. 01-04. DOI: 10.1109/ICISCT52966.2021.9670345

[3] Babomuradov O.J. et al. ”Text documents classification in Uzbek language,” *International journal of recent technology and engineering*, T. 8, № 2, S 11, 2019, pp. 3787-3789.

[4] Biamonte J., Wittek P., Pancotti N., Rebentrost P., Wiebe N., & Lloyd S. “Quantum machine learning,” *Nature*, 549(7671), 2017, pp. 195–202. DOI: 10.1038/nature23474

[5] Babomuradov O.J., Mamatov N.S., Boboyev L.B., & Otaxonova B.I. “Classification of texts using decision trees algorithms,” *Descendants of Muhammad al-Khwarizmi*, *4*(10), 2019.

[6] Babomuradov O.J. et al. “Qapop daraxti algoritmidan foydalanib matnlarni tasniflash,” *Мухаммад ал-Хоразмий авлодлари*, № 4 (10), 2019, p. 22.

[7] Havlíček V., Córcoles A.D., Temme K., Harrow A.W., Kandala A., Chow J.M., & Gambetta J.M. “Supervised learning with quantum-enhanced feature spaces,” *Nature*, 567(7747), 2019, pp. 209–212. DOI: 10.1038/s41586-019-0980-2

[8] Mamatov N.S. et al. “Algorithm for analysis of texts in Uzbek language,” *Artificial Intelligence and Information Technologies*. *CRC Press*, 2025, pp. 511-515.

[9] Niyozmatova N.A. and et al. ”Matnlarni tasniflashda informativ belgilar majmuasini aniqlash usullari,” 2025, pp. 511-515.

[10] Rebentrost P., Mohseni M., & Lloyd S. “Quantum support vector machine for big data classification,” *Physical Review Letters*, 113(13), 2014, p. 130503.

[11] Mamatov N.S. et al. ”Algorithm for analysis of texts in Uzbek language,” *Artificial Intelligence and Information Technologies*. CRC Press, 2025, pp. 511-515.

[12] Schuld M. & Petruccione F. “Machine Learning with Quantum Computers,” *Springer*, 2019.

[13] Turgunov B.Kh. et al. “Algorithms for separating facts from information in Uzbek from applications received from virtual receptions,” Universum: *Technical sciences*, № 12-2 (117), 2023, pp. 9-11.

ACTUAL PROBLEMS OF NATURAL SCIENCES

UDC: 595.44

CHECKLIST OF THE LYCOSIDAE OF UZBEKISTAN

Mardona Bektursunova
Doctorate Student, Department of Zoology, Khorezm Mamun Academy
mardonabektursunovna95@gmail.com

Ikram Abdullaev
Professor, Vice President at Khorezm Mamun Academy
ikram.abdullaev1966@gmail.com

Annotatsiya. Ushbu maqola O‘zbekistonda uchraydigan o‘rgimchaklar (Arachnida: Araneae: Lycosidae) bo‘yicha yangilangan ro‘yxatini taqdim etadi. Bu yangilangan Lycosidae oilasining ro‘yxati taksonomik va evolyutsion adabiyotlarga hamda mualliflarning tadqiqotlariga asoslangan. Lycosidae oilasining ushbu keng qamrovli ro‘yxati O‘zbekiston hududi bo‘yicha shakllantirilgan birinchi to‘plam bo‘lib, 30 turini o‘z ichiga oladi. Shuningdek, tadqiqotimiz davomida *Pardosa proxima* turini ilk bor O‘zbekistonning shimoliy-g‘arbiy qismida qayd etdik.

Kalit so‘zlar: *Araxnidlar, Aranealar, Lycosidae, Markaziy Osiyo, O‘zbekiston, Xorazm vohasi, yangi tur.*

Аннотация. Настоящая статья представляет обновленный список пауков (Arachnida: Araneae: Lycosidae), встречающихся на территории Узбекистана. Этот обновленный список основан на таксономической и эволюционной литературе, а также на исследованиях авторов. Данный обширный список семейства Lycosidae является первым таким собранием для территории Узбекистана и включает 30 видов. Кроме того, в ходе нашего исследования мы впервые зарегистрировали вид *Pardosa proxima* в северо-западной части Узбекистана.

Ключевые слова: *Арахниды, Аранеа, Ликозиды, Центральная Азия, Узбекистан, Хорезмская оазис, новый вид.*

Abstract. This article presents an updated list of spiders (Arachnida: Araneae: Lycosidae) found in Uzbekistan. This revised list of the Lycosidae family is based on taxonomic and evolutionary literature, as well as the research conducted by the authors. This comprehensive list of the Lycosidae family represents the first compilation for the territory of Uzbekistan, including 30 species. Additionally, during our research, we recorded the species *Pardosa proxima* for the first time in the northwestern part of Uzbekistan.

Keywords: *Arachnida, Araneae, Lycosidae, Central Asia, Uzbekistan, Khorezm oasis, new species.*

Introduction

The order Araneae, which includes spiders, represents a significant group of predators that is both diverse and widespread among arthropods worldwide [8, 12]. Spiders significantly contribute to the functioning of natural and artificial ecosystems in roles that are difficult to replicate [26, 13]. Lycosidae is one of the most diverse and most widely distributed families of spiders in the world. It contains 135 genera and 2,491 species and is commonly known as the wolf spiders [27]. In recent years, the Lycosidae family, which has a habitat in the Near East and Central Asia, has been the significant focus of taxonomic research by scientists [15, 17, 18]. The family Lycosidae Sundevall, 1833, found in Central Asia, has been the subject of inadequate research, resulting in a lack of complete taxonomic information [15]. New data is provided about the large-scale distribution geography of the Lycosidae family in Uzbekistan. Additionally, during the study, we recorded the species *Pardosa proxima* for the first time in the northwestern part of Uzbekistan.

The Republic of Uzbekistan is a country in Central Asia, with a total area of 448,900 km². Its territory extends 1,425 kilometers from east to west and 930 kilometers from north to south [1]. The Khorezm oasis is located in the southeastern part of Uzbekistan, in the Amudarya River delta, with coordinates ranging from 41° to 43°N and 58° to 62°E [23]. The climate of the Khorezm oasis is shaped by three main factors: low rainfall, high solar radiation, and an arid continental climate. The mean annual rainfall is 92 mm (ranging from 40 to 160 mm). Most of the precipitation occurs during the spring months, but significant water loss through transpiration results in a net loss of 16 times the annual rainfall. The highest recorded temperature is +28°C, with July temperatures reaching up to +40°C. In contrast, the lowest recorded temperature is -4°C in January, with the potential to drop as low as -32°C [2, 9].

Research Methodology

Researchers often use hand collecting and pitfall traps as methods for gathering spider specimens [3]. In our research, spider collection was carried out mainly from spring to late autumn. The methods used included hand collection and the use of pitfall traps. Spiders collected by hand were placed in 30–50 ml plastic containers while wearing gloves. Pitfall traps were installed in wheat fields and near water bodies, with four traps placed per 1 m² area. The 250 ml plastic containers were filled with a 0.8% NaCl solution and buried in the soil; the solution was renewed every 3–5 days. The tops of the containers were left open. Spiders caught in the traps were transferred to other designated plastic containers. All spiders collected using both methods were preserved in 70% ethanol. The specimens were carefully labeled, and the geographical coordinates and collection dates were recorded. The following map presents a visual representation of the geographic distribution of species belonging to the Lycosidae family (see in Figure 1).

Analysis and Results

Alopecosa cursorioides Charitonov, 1969

Distribution: Uzbekistan, Turkmenistan

Material: Babatagh Ridge, Kafirnighan River Valley, 38°00′ N, 68°17′ E, 25.04.1994; Babatagh Ridge, Ak-Mechet, 38°01′ N, 68°17′ E, 25.04.1994, by S.V. Ovtchinnikov

[21]. Urgench Region, Cholish, 41.655638° N, 60.690433° E; 13.07.2023, by M. Bektursunova and I. Abdullaev.

Alopecosa latifasciata (Kroneberg, 1875)

Distribution: Uzbekistan, Tajikistan?

Material: Tashkent Region, 19 km SSE of Gazalkent, Syurenata Mountains (41°24.1′ N, 69°50.4′ E), 1500 m a.s.l., 4.05.2019, by S.L. Zonstein [19]. Urgench Region, Cholish, 41.655638° N, 60.690433° E; 13.07.2023, by M. Bektursunova and I. Abdullaev.

Alopecosa nigriventris (Schmidt, 1895)

Distribution: Uzbekistan

Material: Uzbekistan, Tashkent Region, Chinaz (ca. 40°57′ N, 68°45′ E), 1878, by Russov [19].

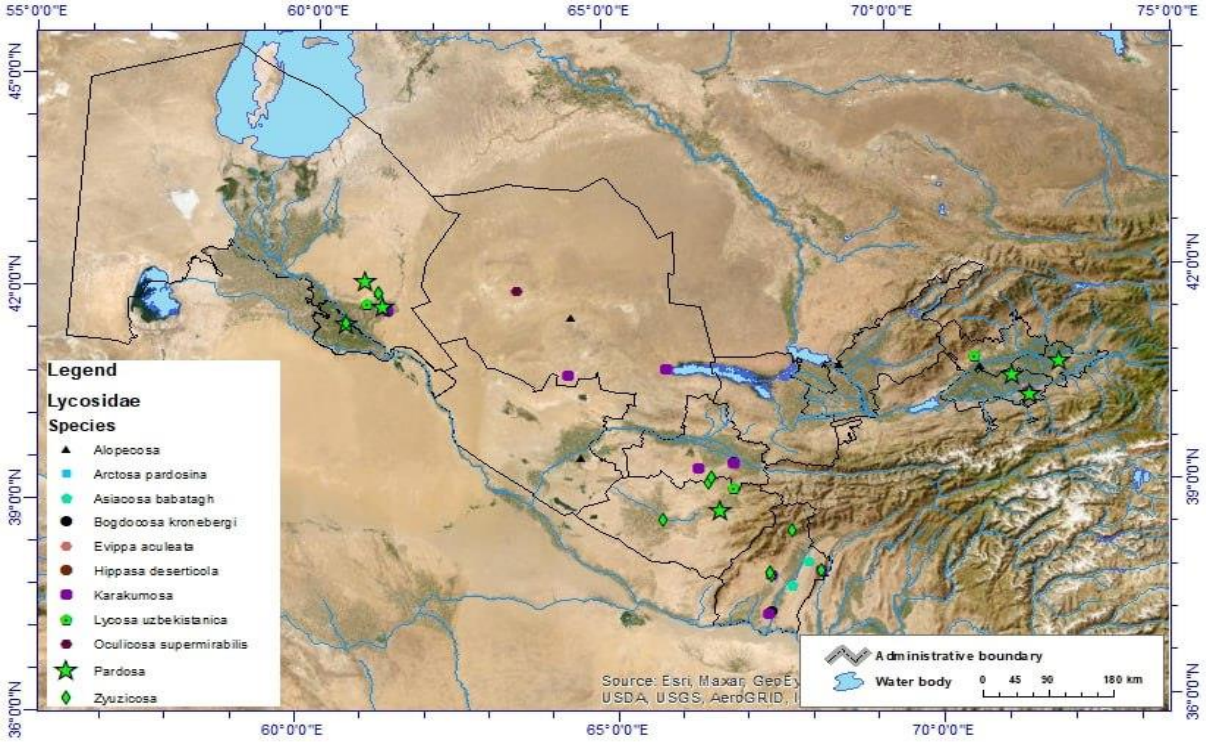

Figure 1. Geographical distribution of Lycosidae species in Uzbekistan.

Family: Lycosidae Sundevall, 1833

Subfamily Lycosinae Simon, 1898

Genus: Alopecosa Simon, 1885

Alopecosa obsolete (C. L. Koch, 1847)

Distribution: Uzbekistan?

Material: Uzbekistan, Bukhara [24]. Urgench region, 41.566142° N, 60.571504° E; 13.07.2023, by M. Bektursunova and I. Abdullaev.

Alopecosa vivax (Thorell, 1875)

Distribution: Ukraine, Russia (Europe), Uzbekistan

Alopecosa zonsteini Logunov, 2023

Distribution: Ukraine, Russia (Europe), Uzbekistan
Material: Namangan Region, 10 km SW of Pap Town, Syr Darya Riverbank (40°48.0′ N, 71°03.1′ E), 370 m a.s.l., 12.04.2019, by S.L. Zonstein [19].

Genus: Arctosa Koch, 1847

Arctosa pardosina (Simon, 1898)
Distribution: Uzbekistan
Material: Fergana Valley, 2022, by Bakhromova [6].

Genus: Asiacosa Logunov, 2023

Asiacosa babatagh Logunov, 2023
Distribution: Uzbekistan
Material: Babatagh Mountain Range, 5 km SW of Ak-Machit Village (= Okma-chit; c. 38°03′18″ N, 68°14′27″ E; c. 1075 m a.s.l.), 28.04.1995, by S.V. Ovtchinnikov; Surkhandaria Region, south foothills of Babatagh Mountains (37°51.4′ N, 67°46.0′ E), 540 m a.s.l., 20.04.2019, by S.L. Zonstein; Surkhandaria Region, south foothills of Babatagh Mountains (38°12.3′ N, 68°03.3′ E), 650–700 m a.s.l., 17.04.2019, by S.L. Zonstein [19].

Genus: Bogdocosa Ponomarev & Belosludtsev, 2008

Bogdocosa kronebergi (Andreeva, 1976)
Distribution: Russia (Caucasus, Central Asia), Azerbaijan, Iran, Kazakhstan, Uzbekistan, Tajikistan, China
Material: Samarkand, 39°39′N, 66°57′E (Kroneberg, 1875: as *T. latifasciata* non Kroneberg, 1875); Larkurgan, 37°30′N, 67°25′E (Andreeva, 1976: as juvenile specimens *A. kronebergi*) [10].

Genus: Evippa Simon, 1882

Evippa aculeata (Kroneberg, 1875)
Distribution: Central Asia
Material: Fergana Valley, 2022, by Bakhromova [6].
Subfamily: Hippasinae

Genus: Hippasa Simon, 1885

Hippasa deserticola Simon, 1889
Distribution: Egypt, Saudi Arabia, Iraq, Iran, Uzbekistan, Turkmenistan, Tajikistan, Afghanistan, Pakistan, India, Bangladesh
Material: Babatagh Mountain Range, Kafirnighan River Valley, 25.IV.1994, by S.V. Ovtchinnikov [22].

Genus: Karakumosa Logunov & Ponomarev, 2020

Karakumosa ferganensis Logunov, 2023
Distribution: Uzbekistan
Material: Fergana (ca. 40°23′ N, 71°47′ E), 18.05.1878, by Kushakevitch [19].

Karakumosa gromovi Logunov & Ponomarev, 2020
Distribution: Uzbekistan
Material: Surxondaryo Region, Baisun [= Boysun] District, ca. 44 km SW of Denau [= Denov], SE foothills of Dzhetymkalyas Mountain Range (38°01′10.6″ N, 67°28′06.3″ E), ca. 640 m a.s.l.; 13-14 V. 1994, by A.V. Gromov [18].

Karakumosa ovtchinnikovi Logunov, 2023
Distribution: Uzbekistan

Material: Babatagh Mountain Range, 5 km SW of Ak-Machit Village (= Okmachit; ca. 38°03′18″ N, 68°14′27″ E), ca. 1075 m a.s.l., 28.04.1995, by S.V. Ovtchinnikov [19].

Karakumosa sogdiana Logunov, 2024

Distribution: Uzbekistan, Turkmenistan

Material: Navoi Region, Nurota District, near Koshkuduk, western shore of Aydar Lake (approx. 40°59′N, 65°55′E), desert, 13.08.2023, V.S. Turitsin; same locality, 28–29.08.2023, V.S. Turitsin; same locality, 27.06.2021, V.S. Turitsin; Surxondaryo Region, southwest outskirts of Dzharkurgan, near Dekhkanabad (approx. 37°28′N, 67°22′E), desert, 7.08.2023, V.S. Turitsin [20]. Khiva Region, 41.405796° N, 60.386974° E; 04.08.2023, by M. Bektursunova and I. Abdullaev.

Karakumosa turanica Logunov & Ponomarev, 2020

Distribution: Iran, Turkmenistan

Material: [UZBEKISTAN], “Ulus” (ca. 39°34′ N, 66°22′ E); no date; leg. [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science). – ZMMU, Ta-1216; 1 subadult male, 3 immature females (paralectotypes of *Tarentula alticeps*); [UZBEKISTAN], Samarkand (ca. 39°37′ N, 66°57′ E); no date; leg. [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science) [18].

Karakumosa zyuzini Logunov & Ponomarev, 2020

Distribution: Iran, Uzbekistan

Material: Navoiy Region, Kanimekh District, near Chengeldy (ca. 40°56′44.1″ N, 64°18′06.0″ E), flat clay clough between sandy plots; 22-23 V. 1994, by A.A. Zyuzin [18]. Khiva Region, 41.405796° N, 60.386974° E; 04.08.2023, by M. Bektursunova and I. Abdullaev.

Genus:** Lycosa **Latreille, 1804

Lycosa uzbekistanica Logunov, 2023

Distribution: Uzbekistan, Kazakhstan?

Material: Kashkadarie Region, Zeravshan Mountains, Aman Kutan Pass (39°17.3′ N, 66°56.2′ E), 1730 m a.s.l., 22.04.2019, by S.L. Zonstein; Namangan Region, Kuramin Mountains, 8 km NW of Uigursal (40°57.7′ N, 70°58.3′ E), 830 m a.s.l., 13.04.2019, by S.L. Zonstein [19]. Urgench region, 41.566142, 60.571504; 13.07.2023 by M.Bektursunova and I.Abdullaev.

Genus:** Oculicosa **Zyuzin, 1993

Oculicosa supermirabilis Zyuzin, 1993

Distribution: Kazakhstan, Uzbekistan, Turkmenistan

Material: Western Uzbekistan [16]. Urgench Region (41.5505° N, 60.74489° E), 13.07.2023, by M. Bektursunova and I. Abdullaev.

Genus:** Pardosa **C. L. Koch, 1847

Pardosa ovtchinnikovi Ballarin, Marusik, Omelko & Koponen, 2012

Distribution: Iran, Turkmenistan, Uzbekistan, Tajikistan

Material: Babatagh Mountain Range, Kafirnighan River Valley, 25.04.1994, by Ovtchinnikov [7].

Genus:** Pardosa **C. L. Koch, 1847

Pardosa zonsteini Ballarin, Marusik, Omelko & Koponen, 2012

Distribution: Iran, Kazakhstan, Central Asia

Material: Bukhara area, Yakkabagh, 38°58′47″ N, 66°41′48″ E, 24.03.1942, by D.M. Fedotov; Fergana area, Yar'yavan District, Karakalpak Steppe, approximately 13.5 km west of Yaz'yavan, Populus forest, around 400 m, 40°39′01″ N, 71°33′51″ E, 19.05.2002, by Gromov [F. Ballarin et all., 2012]. Fergana Valley, 2022, by Bakhromova [6].

Genus: *Pardosa* ***C. L. Koch, 1847***

Pardosa nebulosa (Thorell, 1872)

Distribution: Italy, Central Europe to Greece and Ukraine, Turkey, Caucasus, Russia (Europe to South Siberia), Kazakhstan, Iran, Central Asia, China

Material: Fergana Valley, 2022, by Bakhromova [6]; Khorezm Oasis, Yangibozor National Park, coordinates: 41.768238, 60.551271, 01.06.2024, by M. Bektursunova and I. Abdullaev.

Genus: *Zyuzicosa* ***Logunov, 2010***

Zyuzicosa andreii Fomichev, 2023

Distribution: Uzbekistan

Material: Surxondaryo Region, Hisar Mountains, Tupalangdarya River valley, 7 km NNE of Gisarak Village, 38°38.113′N, 67°49.661′E, stony montane shrubland with rocks, 1000–1300 m, 01–02 May 2022, by A. A. Fomichev [11].

Zyuzicosa baisunica Logunov, 2010

Distribution: Uzbekistan

Material: Surkhandarya Area, Baisun [= Boysun] District, ca. 46 km WSW of Denau [= Denov], SE foothills of Dzhetymkalyas Mountain Range, clayey slopes, 38°01′45″ N, 67°27′20″ E, 700–800 m a.s.l., 13-14.05.1994, by A.V. Gromov, A.A. Zyuzin [15]. Khiva Region (41.405796° N, 60.386974° E), 04.08.2023, by M. Bektursunova and I. Abdullaev.

Zyuzicosa fulviventris (Kroneberg, 1875)

Distribution: Uzbekistan

Material: Samarqand Area, Nurabad District, SW slope of Zeravshan Mountain Range, Dzham (39°22′50″ N, 66°31′00″ E), 850–1000 m a.s.l., 8.06.1991, by E.E. Koptykbaev, A.A. Zyuzin [14, 15].

Zyuzicosa gigantean Logunov, 2010

Distribution: Uzbekistan

Material: Surkhandarya Area, Baisun [= Boysun] District, ca. 46 km WSW of Denau [= Denov], SE foothills of Dzhetymkalyas Mountain Range, clayey slopes, 38°03′00″ N, 67°26′30″ E, 850–950 m a.s.l., 12–13.05.1994, by A.A. Zyuzin [15]. Urgench region, Cholish 41.655638, 60.690433; 13.07.2023 by M.Bektursunova and I.Abdullaev.

Zyuzicosa nenjukovi (Spassky, 1952)

Distribution: Tajikistan, Uzbekistan

Material: Karshi (Bukhara) [now Qarshi, ca. 38°51′ N, 65°47′ E], 1882, by Grum-Grzymailo. Urgench Region, Cholish (41.655638° N, 60.690433° E), 13.07.2023, by M. Bektursunova and I. Abdullaev.

Zyuzicosa turlanica Logunov, 2010

Distribution: Kazakhstan, Uzbekistan
Material: Chon–Kaimysh (39°26′49.4″ N, 66°35′38.6″ E) [15, 17].
Zyuzicosa uzbekistanica Logunov, 2010
Distribution: Uzbekistan
Material: Surkhandarya Area, Baisun [= Boysun] District, ca. 46 km WSW of Denau [= Denov], SE foothills of Dzhetymkalyas Mountain Range, clayey slopes, 38°03′00″ N, 67°26′30″ E, 850–950 m a.s.l., 13.05.1994, by O.V. Lyakhov; Dzhetymkalyas Mountain Range (38°03′00″ N, 67°26′30″ E), Babatagh Mountain Range (38°03′18″ N, 68°14′27″ E), elevation: ca. 1075 m a.s.l. [15, 17].

New record: Genus: *Pardosa* ***C. L. Koch, 1847***

Pardosa proxima (Thorell, 1872)
Distribution: Macaronesia, northern Africa, Europe, Caucasus, Russia (Europe to Far East), Kazakhstan, Iran, Central Asia, China
Material: This species was recorded for the first time in Uzbekistan, in Khiva District, near the lake, coordinates: 41.405796, 60.386974., 30.03.2025, by M. Bektursunova and I. Abdullaev.

Conclusion

Wolf spiders of the family Lycosidae are ground-dwelling creatures, yet they remain insufficiently studied in Central Asia, which encompasses the regions of Middle Asia, Tibet, Pakistan, Afghanistan, Iran, and western China that border Kazakhstan [3]. These spiders are classified in the subfamily Lycosinae and the tribe Lycosini**;** however, the validity of the latter tribe has not been strongly supported by researchers [25]. Recent studies have documented at least 17 species of lycosids in Central Asia, highlighting a notable diversity of this enigmatic fauna. The exact number of species remains undetermined due to a lack of understanding regarding their taxonomy. The limited documentation of Central Asian lycosids is further compounded by the small number of recorded instances, with most species having only a handful of documented observations. Additionally, the scarcity of information on the biology of these species is exacerbated by the absence of comprehensive taxonomic treatments [15].

This overview is primarily based on the information from scientific articles as well as the research conducted by Bektursunova and Abdullayev in the territory of Uzbekistan during 2024-2025.

References:

[1] Abdullaev U., Abdullaev I., Gandjaeva L. “The social wasp fauna of riparian tuqai forest in Khorezm region Uzbekistan (Hymenoptera, Vespidae),” *International Journal of Current Research and Review*, 12 (14), 2020, pp. 96-99. DOI: 10.31782/IJCRR.2020.121420
[2] Allabergenov T.X. “Environmental conditions of Khorezm oasis and its zoning,” Tashkent: *O’qituvchi*, 1976.
[3] Alexey Z. “Studies on burrowing spiders of the family Lycosidae (Araneae),” *Preliminary data on structural and functional features*, 1990.
[4] Alireza Zamani, Omid Nadolny, Esyunin S.L., Marusik Y.M. “Newdata on the spider fauna of Iran (Arachnida: Araneae),” Part IX.
[5] Azarkina G.N., Esyunin S. L., Kuz’min, E. A., & Marusik, Y.M. “On the synonymy of two wolf spider species of the genus *Alopecosa* (Araneae, Lycosidae) from the steppe zone of Russia,” *Zootaxa*, 4205(4), 2016. DOI: 10.11646/zootaxa.4205.4.2

[6] Bakhromova B. "Fauna and ecology of spiders (Arachnida: Araneae) of the Ferghana valley," *Dissertation*, Fergana, 2022.
[7] Ballarin F., Marusik Y.M., Omelko M.M., Koponen S. On the *Pardosa monticola* species-group (Araneae: Lycosidae) from Middle Asia," *Rej*, 21(1), 2012, p. 1611820. DOI: 10.15298/arthsel.21.2.05
[8] Dippenaar-Schoeman A.S., Van Den Berg A.M., Haddad C.R., Lyle R. "Current knowledge of spiders in South African agroecosystems (Arachnida, Araneae)," *Transactions of the Royal Society of South Africa*. 68(1), 2013, pp. 57-74. DOI:10.1080/0035919x.2012.755136
[9] Eshchanov R.A. "Agro ecological bases of sustainable use land and water resoures (in case of Khorezm region)," Tashkent: *Avtoref. Dissertation of doctor in biological sciences*, 2008.
[10] Esyunin S.L., Ponomarev A.V. "Taxonomic remarks on the genus *Bogdocosa* Ponomarev et Belosludtsev 2008 (Aranei: Lycosidae)," *Rej*, 27(1), 2018, p. 610680. DOI: 10.15298/arthsel.27.1.09
[11] Fomichev A.A. "A New Species of *Zyuzicosa* Logunov, 2010 (Araneae: Lycosidae) from Uzbekistan," *Arachnology*, 19(6), 2023. DOI: 10.13156/arac.2023.19.6.952
[12] Gaigher R., Samways M.J. "Landscape mosaic attributes for maintaining ground-living spider diversity in a biodiversity hotspot," *Insect Conservation and Diversity*, 7(5), 2014, pp. 470–479. DOI: 10.1111/icad.12070
[13] Joseph G.S., Mauda E.V., Seymour C.L., Munyai T.C., Dippenaar-Schoeman A., Foord S.H. "Landuse change in savannas disproportionately reduces functional diversity of invertebrate predators at the highest trophic levels: spiders as an example," *Ecosystems*, 21(5), 2017, pp. 930-942. DOI: 10.1007/s10021-017-0194-0
[14] Kronenberg A. "Spiders," Fedchenko A.P., *Journey to Turkestan*, St. Petersburg, Moscow, *Proceedings of the Imperial Society of Naturalists, Anthropology and Ethnography*, Volume XIX, Issue 3, 1875, pp. 1-56.
[15] Logunov D. "On new Central Asian genus and species of wolf spiders (Araneae: Lycosidae) exhibiting a pronounced sexual size dimorphism," *Proceedings of the Zoological Institute RAS*, 314(3), 2010, pp. 233-263. DOI: 10.31610/trudyzin/2010.314.3.233
[16] Logunov D.V., Gromov A.V. "Notes on the distribution of *Oculicosa supermirabilis* (Araneae, Lycosidae)," *Arachnologische Mitteilungen Arachnology Letters*, *42*, 2011, pp. 48–51. DOI: 10.5431/aramit4208
[17] Logunov D.V. "A synopsis of the genus *Zyuzicosa* Logunov, 2010 (Aranei: Lycosidae)," *Rej*, 21(1), 2012, pp. 349362–0. DOI: 10.15298/arthsel.21.4.05
[18] Logunov D.V., Ponomarev A.V. "*Karakumosa* gen. nov., a new Central Asian genus of fossorial wolf spiders (Araneae: Lycosidae: Lycosinae)," *Global Biodiversity Information Facility*, 2020. DOI: 10.15468/an2zhq
[19] Logunov D.V. "Further notes on the fossorial wolf spiders of Middle Asia and the Near East (Aranei: Lycosidae)," *Rej*, 32(4), 2023, pp. 475–512. DOI: 10.15298/arthsel.32.4.12
[20] Logunov D.V. "On two *Karakumosa* species (Aranei: Lycosidae), with new faunistic records for three fossorial wolf-spiders from Middle Asia and the Caucasus," *Rej*, 33(3), 2024, pp. 407–416. DOI: 10.15298/arthsel.33.3.09
[21] Marusik Y.M., Nadolny A.A., Koponen S. "A survey of the *Alopecosa cursor* species group (Aranei: Lycosidae) from Asia," *Rej*, 27(1), 2018, pp. 348–362. DOI: 10.15298/arthsel.27.4.12
[22] Marusik, Y., Nadolny A. "Redescription of *Hippasa deserticola*, the northernmost species of Hippasa (Aranei: Lycosidae), with taxonomic notes on other species of the genus," *Zoosystematica Rossica*, 30(2), 2021, pp. 222–235. DOI: 10.31610/zsr/2021.30.2.22

[23] Matchanov M., Teodoro A., Schroder C. “Criterion definition for the identification of physical-geographical boundaries of Khorezm oasis through remotely sensed data,” *Environmental Monitoring and Assessment*, 188(1), 2015. DOI: 10.1007/s10661-015-5035-z

[24] Mikhailov K.G. “Tarentula Sundevall, 1833 and Alopecosa Simon, 1885: a historical account (Aranei: Lycosidae),” *Rej*, 22(1), 2013, pp. 259263–0. DOI: 10.15298/arthsel.22.3.0

[25] Murphy N.P., Framenau V.W., Donnellan S.C., Harvey M.S., Park Y., Austin A.D. “Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: Implications for classification, biogeography, and the evolution of web building behavior,” *Molecular Phylogenetics and Evolution*, 38(3), 2006, pp. 583–602. DOI: 10.1016/j.ympev.2005.09.004

[26] Neethling J.A., Haddad C.R. “Arboreal spider assemblages associated with four tree species in the Grassland Biome of central South Africa (Arachnida: Araneae),” *Transactions of the Royal Society of South Africa*, 68(2), 2013, pp. 123–131. DOI: 10.1080/0035919x.2013.806374

[27] User G. “Occurrence download [Dataset],” In *Global Biodiversity Information Facility*, 2023. DOI: 10.15468/dl.5qyxsz

UDC: 59, 591, 591.1

THE EFFECT OF PS-5 AND PLANTAGIN COMPOUNDS ON THE ATP-SENSITIVE POTASSIUM CHANNEL IN THE MITOCHONDRIAL MEMBRANE

Karimjonov Khayotbek Mirodilbek Ugli
Andijan State University named after Z.M. Bobur

Gayibov Ulugbek Gapparjanovich
Academy of Sciences of Uzbekistan Institute of Bioorganic Chemistry named after Abid Sadykovich Sadykov
gayibov.ulugbek@gmail.com

Rakhimov Rakhmatilla Nuraliyevich
Academy of Sciences of Uzbekistan Institute of Bioorganic Chemistry named after Abid Sadykovich Sadykov

Zaynabiddinov Anvar Erkinjonovich
Andijan State University named after Z.M. Bobur

Makhmudov Rustamjon Rasuljonovich
Academy of Sciences of Uzbekistan Institute of Bioorganic Chemistry named after Abid Sadykovich Sadykov

Annotatsiya. Ushbu maqolada Rhus glabra va Plantago majordan ajratilgan taninlarning kalamush jigar mitoxondriyalarida ATPga bog‘liq kaliy kanali faoliyatiga ta’siri baholandi. Natijalar shuni ko‘rsatdiki, bu birikmalar mitoKATP kanalini uning blokeri glibenclamid borligida ham faollashtirishga qodir.

Kalit so‘zlar: *PS-5, plantagin, mitoKATP kanali, bloker, glibenklamid, kardioprotektor.*

Аннотация. В этой статье оценивалось влияние танинов, выделенных из Rhus glabra и Plantago major, на активность АТФ-зависимого калиевого канала в митохондриях печени крыс. Результаты показали, что эти соединения способны активировать митоКАТФ-канал даже в присутствии его блокатора, глибенкламида.

Ключевые слова: *PS-5, плантагин, митоКАТФ-канал, блокатор, глибенкламид, кардиопротектор.*

Abstract. In this article, the effects of tannins isolated from *Rhus glabra* and *Plantago major* on the activity of the ATP-dependent potassium channel in rat liver mitochondria were evaluated. The results showed that these compounds were able to activate the mitoK_{ATP} channel even in the presence of its blocker, glibenclamide.

Keywords: *PS-5, plantagin, mitoK_{ATP} channel, blocker, glibenclamide, cardioprotector.*

Introduction

KATF channels belong to the ATP-binding cassette transporter (ABC transporter) superfamily and are composed of two subunits: the pore-forming inwardly rectifying potassium channel subunit (Kir) and the regulatory sulfonylurea receptor (SUR) [1].

The Kir and SUR subunits interact to form a fully functional complex. Within the channel, the Kir subunit functions as an ATP-dependent potassium channel. The molecular mass of the mitochondrial Kir subunit is 55 kD, while the molecular mass of the mitochondrial SUR subunit is 63 kD [2].

Furthermore, these two subunits assemble in a 4:4 ratio to form the active form of the KATF channel, forming a hetero-octamer stoichiometry [3].

MitoKATF channels were first identified in 1991 by single-channel recordings from the inner mitochondrial membrane [6]. These channels were initially identified in liver mitochondria and later in the inner membrane of heart mitochondria [7]. According to the data presented in the literature, compounds that increase the activity of these channels are considered as potential cardioprotective agents.

Based on the above, the aim of this work is to study the effect of hydrolyzable tannins isolated from Rhus glabra and Plantago major on the activity of the mitoKATF channel.

Research Methodology

The experiments were conducted on outbred white male rats weighing 180-200 g. Feeding of laboratory animals was carried out in vivarium conditions under standard rational conditions. Scientific research on experimental animals was carried out in accordance with the International Declaration of Helsinki and the rules developed by the Council for International Organizations of Medical Sciences (CIOMS; the Council for International Organizations of Medical Sciences) (1985).

Method for isolating mitochondria from liver tissue.

Rat liver mitochondria were isolated using the differential centrifugation method of W.C. Schneider [8]. Rats were euthanized by decapitation, and the liver was removed and placed in a buffer solution with a pH of 7.4 (sucrose-250 mM, tris NCl-10 mM, EDTA-1 mM). The liver mass was weighed and passed through a micropress with 1 mm holes for grinding. A cooled buffer solution was added to the minced liver tissue in a ratio of 1:6 and homogenized using a special homogenizer (HG-15A). The resulting homogenate was centrifuged (temperature 0-2 °C), and the centrifugation process was carried out in 2 stages. In the first stage, centrifugation lasted 7-8 minutes at a speed of 1500 rpm (relative centrifugal acceleration 600 g). This precipitated the cell debris and nuclear fractions. In the next step, the supernatant was poured into a centrifuge tube and centrifuged at 6000 rpm (6000 g) for 15 minutes. After that, the supernatant was removed, and the precipitated mitochondria were washed with EDTA-free buffer solution and stored in a refrigerator in a container with ice.

Determination of ATP-dependent potassium channel activity in rat liver mitochondria.

The kinetics of mitochondrial swelling (0.3-0.4 mg/ml protein) was determined by stirring the mitochondrial suspension at 26 °C. MitoKATF channel permeability (0.3-0.4 mg/ml protein) was determined by measuring the change in optical density at 540 nm in 3 ml wells. The IM was as follows: 125 mM KCl, 10 mM HEPES, 5 mM

succinate, 1 mM MgCl2, 2.5 mM K2HPO4, 2.5 mM KH2PO4, 0.005 mM rotenone and 0.001 mM oligomycin, pH 7.4 [9].

Analysis and Results

The ATP-dependent potassium channel is a member of the ATP-binding transporter superfamily and consists of two parts: the potassium channel-forming part (Kir) and the regulatory sulfonylurea receptor (SUR). Both parts are required for the channel to function fully. In this case, Kir and SUR interact to form the ATP-dependent potassium channel. The Kir part in the mitochondrial membrane has a molecular mass of 55 kDa, and the SUR part has a molecular mass of 63 kDa [1]. Both parts are formed in a stoichiometric ratio of 4:4 in the formation of the ATP-dependent potassium channel. According to a number of data presented in the literature, potassium channel activators have shown potential cardioprotective and vasorelaxant properties in clinical trials [10]. However, data on biologically active substances that affect the functional activity of the mitoKATF channel are very rare in the literature. Therefore, we began our study by studying the effects of PS-5 and plantagin on the activity of ATP-dependent potassium channels. To this end, the effects of PS-5 and plantagin on mitoKATP channels isolated from healthy rat liver were first studied in vitro (see Figure 1).

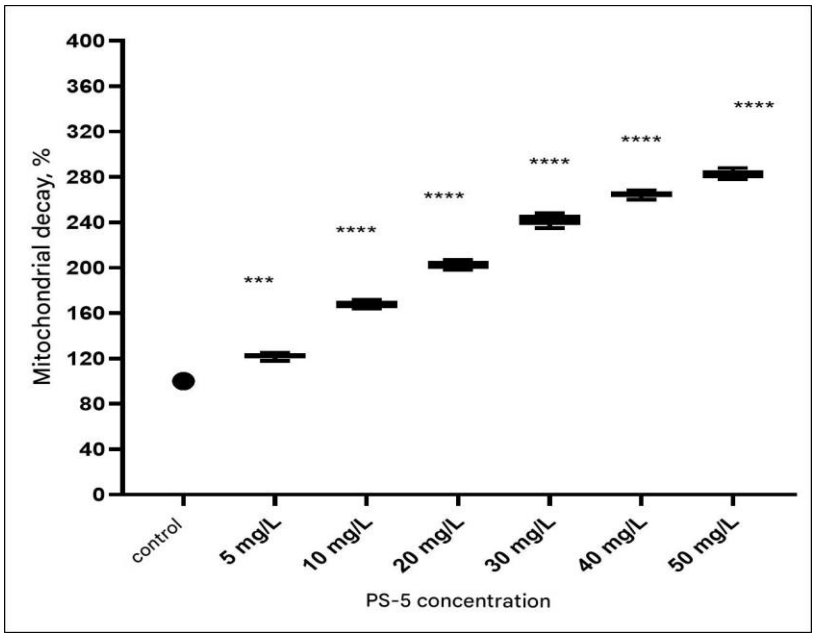

Figure 1. Effect of PS-5 on rat liver mitoKATF channel. (IM: (in mM) 125 KCl, 1 MgSO4, 2.5 K2HPO4, 2.5 KH2PO4, 10 Hepes, 5 succinate, rotenone 5 μg/ml, 1 μg/ml oligomycin pH-7.4. Statistical significance - *-p<0.05; **-p<0.01; ***-p<0.001; ****-p<0.0001; n=5).

According to the results obtained, PS-5 had an activating effect on the mitoKATF channel in the membrane of mitochondria isolated from hepatocytes. In the presence of ATP in IM, PS-5 at a concentration of 5 mg/L activated the channel activity by 22.4±1.1 % compared to the control. It was found that concentrations of PS-5 of 10, 20, 30, and 40 mg/L activated the mitoKATF channel by 67.8±1.4 %, 102.6±3.2 %, 142.0 %, and 164.8 %, respectively, compared to the control. Under the influence of a concentration of 50 mg/L of the compound, the activity of the liver mitoKATF channel increased by 182.6±6.7%. Thus, the results obtained show that PS-5 activates the liver

mitoKATF channel in vitro. The statistical significance of the results was p<0.001 at the 5 mg/L concentration compared to the control, and p<0.0001 at the remaining concentrations.

In further experiments, the effect of plantagin on mitoKATF-channel activity was determined. It was found that plantagin also has an activating effect on the mitoKATF channel when exposed to it. In the presence of ATP in the IM, 5 mg/L plantagin activated the channel activity by 12.4±1.1 % compared to the control. It was found that concentrations of 10, 20, 30, and 40 mg/L of plantagin activated the mitoKATF-channel by 57.8±1.4 %, 87.6±3.2 %, 127.2 %, and 144.8±6.7 %, respectively, compared to the control. The concentration of the compound at 50 mg/L increased the activity of the hepatic mitoKATF-channel by 162.6±6.9 % (see Figure 2). Thus, the results obtained show that plantagin also activates the hepatic mitoKATF channel in vitro. The statistical significance of the results obtained was p<0.01 at the 5 mg/L concentration and p<0.001 at the remaining concentrations compared to the control.

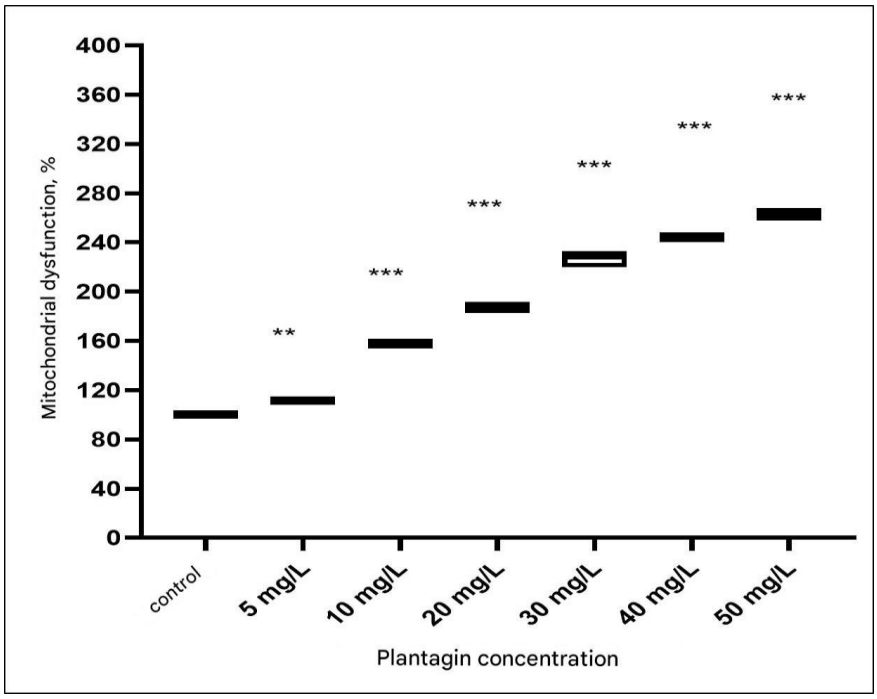

Figure 2. Effect of plantagin on rat liver mitoKATF-channel (P<0.001; n=5). The composition of IM is presented in Figure 3.1 (Reliability of statistical indicators - *-P<0.05; **-P<0.01; ***-P<0.001; ****-P<0.0001; n=5).

It is known that glibenclamide is one of the classical and most studied selective blockers of potassium channels [9]. It is precisely because of this property that glibenclamide is widely used in scientific practice to determine the activity of ATP-sensitive potassium channels, in particular mitochondrial KATP (mitoKATP) channels. The use of blockers of this type is relevant and necessary for the reliable determination of channel activity and confirmation of the specificity of the results obtained.

In our study, additional experiments were conducted to determine the effect of PS-5 and plantagin compounds on the mitoKATP channel. At this stage, glibenclamide was used to assess the functional state of KATP channels located in the mitochondrial

membrane. It turned out that PS-5 and plantagin compounds increased the activity of the mitoKATP channel even in the presence of glibenclamide. This indicates that these polyphenol compounds directly or indirectly affect the channel.

The observed increase in channel activity also indicates the influx of K+ ions into the mitochondrial matrix. This ion influx activates important protective mechanisms such as balancing the mitochondrial membrane potential, reducing excess calcium ions, and reducing oxidative stress. Therefore, the positive results observed in the presence of glibenclamide further confirm the potential cardioprotective properties of these compounds. Overall, the experiments conducted in combination with glibenclamide demonstrate the direct activating effect of PS-5 and plantagin on the mitoKATP channel and shed light on their role in activating protective mechanisms in cardiac tissue. Based on these results, it is relevant to study these polyphenol compounds from a therapeutic perspective in pathological conditions associated with cardiac ischemia, reperfusion injury, and other oxidative stress.

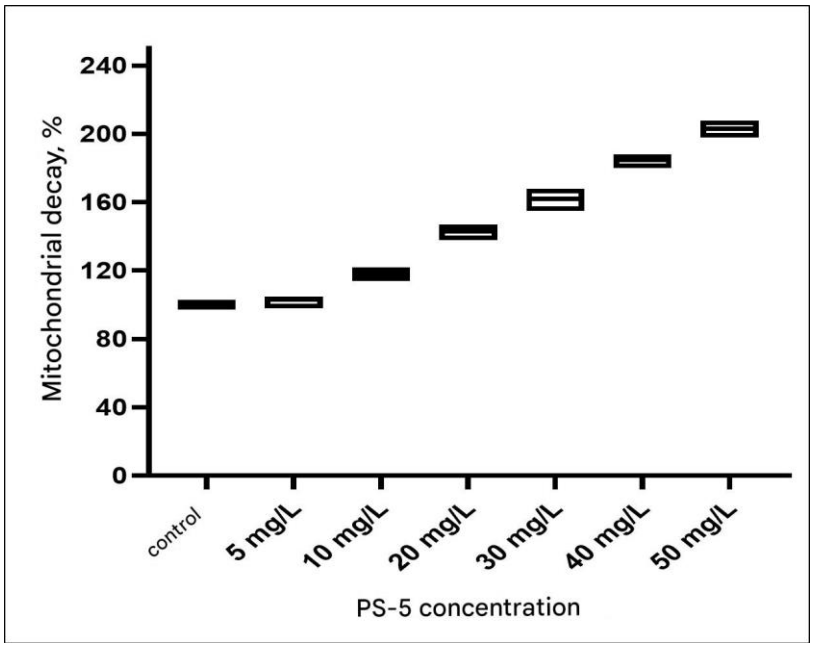

Figure 3. Effect of PS-5 on rat liver mitoKATF channel in the presence of channel blocker (IM: (in mM) 125 KCl, 1 MgSO4, 2.5 K2HPO4, 2.5 KH2PO4, 10 Hepes, 5 succinate, rotenone 5 µg/ml, 1 µg/ml oligomycin, 5 µg/ml glibenclamide pH 7.4. Statistical significance - *-P<0.05; **-P<0.01; ***-P<0.001; ****-P<0.0001; n=5).

According to the results obtained, PS-5 had an activating effect on the mitoKATF-channel isolated from liver cells. In the presence of ATP and glibenclamide in IM, PS-5 at a concentration of 5 mg/L activated the channel activity by 19.4±1.1 % compared to the control (see Figure 3). It was found that concentrations of PS-5 of 10, 20, 30 and 40 mg/L activated the mitoKATF-channel by 37.8±2.4 %, 2.6±4.2 %, 82.1±3.8 % and 104.8±4.8 %, respectively, compared to the control. Under the influence of a concentration of 50 mg/L of the compound, the activity of the hepatic mitoKATF-channel increased by 122.6±7.7 %. Thus, the results obtained show that PS-5 activates the hepatic mitoKATF channel in vitro even in the presence of its classic blocker,

glibenclamide. The statistical significance of the results obtained was $p<0.001$ at a concentration of 5 mg/L compared to the control, and $p<0.0001$ at other concentrations.

In subsequent experiments, the effect of plantagin on mitoKATF channel activity was determined in the presence of its blocker, glibenclamide. It was found that plantagin also has an activating effect on the mitoKATF channel. In the presence of ATP and glibenclamide in IM, 5 mg/L plantagin activated the channel activity by 2.7±1.0 % compared to the control. Plantagin concentrations of 10, 20, 30, and 40 mg/L were found to activate mitoKATF-channel by 17.2±2.4 %, 42.4±4.1 %, 62.0±6.1 %, and 84.3±7.2 %, respectively, compared to the control (see Figure 4).

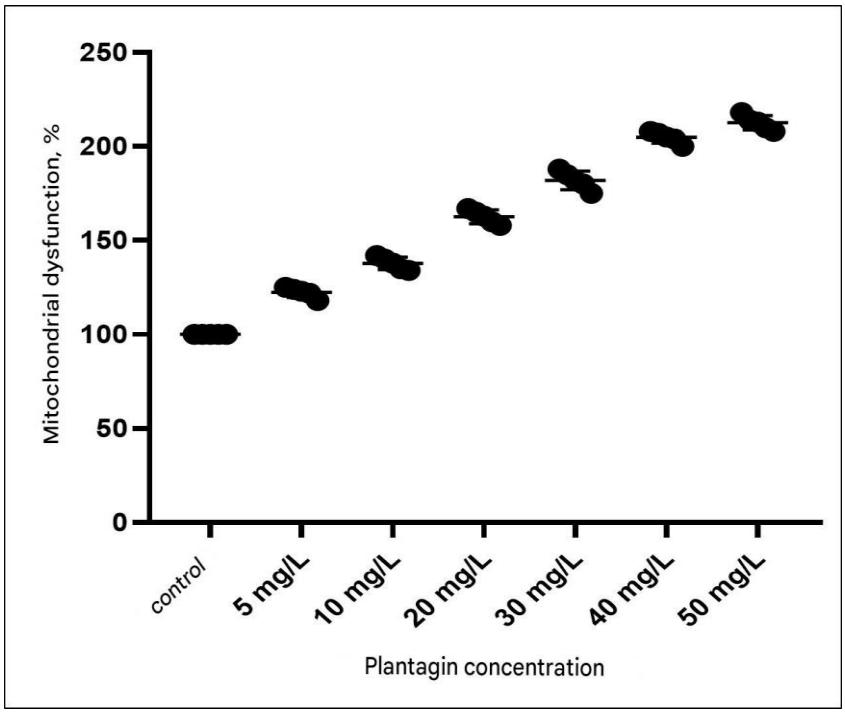

Figure 4. Effect of plantagin on rat liver mitoKATP channel in the presence of a channel blocker (IM: (in mM) 125 KCl, 1 MgSO4, 2.5 K2HPO4, 2.5 KH2PO4, 10 Hepes, 5 succinate, rotenone 5 μg/ml, 1 μg/ml oligomycin, 5 μg/ml glibenclamide pH 7.4. Statistical significance - *-P<0.05; **-P<0.01; ***-P<0.001; ****-P<0.0001; n=5).

The highest concentration of the compound, 50 mg/L, increased the activity of the hepatic mitoKATF-channel by 102.4±7.9 %. Thus, the results obtained show that plantagin also activates the hepatic mitoKATF-channel in vitro. The statistical significance of the results obtained was $p<0.01$ at the 5 mg/L concentration compared to the control, and $p<0.001$ at the remaining concentrations.

Conclusion

As a result of the conducted studies, it was found that the compounds PS-5 and plantagin have an activating effect on the activity of the mitochondrial ATP-sensitive potassium channel (mitoKATP). In particular, these compounds were observed to increase the activity of the channel in the presence of a selective blocker of glibenclamide. This indicates that their activating effect is strong and stable.

These results substantiate the potential of PS-5 and plantagin compounds to protect cells from oxidative stress and ischemia-reperfusion injury through mitoKATP

channels. Thus, these compounds can be considered as promising cardioprotective agents of natural origin, which have the property of protecting cardiac tissues under conditions of energetic and oxidative stress.

In the future, it is necessary to develop new pharmacological drugs based on these compounds and conduct extensive research on their use in diseases of the cardiovascular system.

References:

[1] McCully J.D., Levitsky S. “The mitochondrial (KATF) channel and cardioprotection,” *Ann Thorac Surg*. Vol. 75, 2003, pp. 667-673.

[2] Garlid K.D., Paucek P. “The mitochondrial potassium cycle,” *IUBMB Life,* Vol. 52, 2001, pp. 153-158.

[3] Snyders D.J. “Structure and function of cardiac potassium channels,” Cardiovasc Res. Vol. 42, 1999, pp. 377-390.

[4] Inoue I., Nagase H., Kishi K., Higuti T. “ATP-sensitive K+ channel in the mitochondrial inner membrane,” Nature, Vol. 352, 1991, pp. 244-247.

[5] Aittoniemi J., Fotinou C., Craig T.J., de Wet H., Proks P., Ashcroft F.M. “SUR1: a unique ATPbinding cassette protein that functions as an ion channel regulator,” Review. *Philos Trans R Soc Lond B Biol Sci.,* Vol. 364, 2009, pp. 257-267.

[6] Schneider W.C., Hageboom G.H., Pallade G.E. “Cytochemical studies of mammalian tissues; isolation of intact mitochondria from rat liver; some biochemical properties of mitochondria and submicroscopic particulate material,” *J. Biol. Chem.* Vol. 172 (2), 1948, pp. 619-635.

[7] Vadzyuk O.B., Kosterin S.A. “Indutsirovannoe diazoksidom nabuxanie mitoxondriy miometriya krьıs kak svidetelstvo aktivatsii ATR-chuvstvitelnogo K+-kanala,” *Ukr. bioxim. jurn.* Vol. 80(5), 2008, pp. 45-51.

[8] Ankur Rohilla et al. “Mitochondrial ATP-Sensitive Potassium Channels and Cardioprotection,” *International journal of drug Devolopment*, Vol. 4, 2012, pp. 92-98.

[9] Mironova G.D., Negoda A.E., Marinov B.S., et al. “Functional distinctions between the mitochondrial ATP-dependent K+ channel (mitoKATP) and its inward rectifier subunit (mitoKIR),” *J. Biol. Chem.* Vol. 279(31), 2004, pp. 32562-32568.

UDC: 904, 930.2, 94

THE STUDY OF TRADITIONAL AESTHETICS OF CHINESE MUSIC IN PIANO WORKS

Wang Ping
Independent Researcher, Andijan State Pedagogical Institute, Suqian University, Suqian 223800, China
14009375@qq.com

Annotatsiya. Xitoy va G‘arb musiqa madaniyati uyg‘unligining badiiy ochiqlanishi sifatida Xitoy pianino asarlari ijodiy amaliyotida chuqur an’anaviy estetik g‘oyalarni o‘z ichiga oladi. “Fortepiano asarlarida xitoy musiqasining an’anaviy estetikasini o‘rganish” deb nomlangan ushbu tadqiqot Xitoy an’anaviy estetik g‘oyalarining nazariy kelib chiqishi va pianino musiqasi ijodidagi amaliy ko‘rinishlarini tizimli ravishda o‘rganadi. Tadqiqot shuni ko‘rsatadiki, xitoylik pianino asarlari nafaqat Xitoy musiqa madaniyatining estetik xususiyatlarini saqlab qolgan, balki an’anaviy estetik g‘oyalarni zamonaviy ijodiy uslublar bilan uyg‘unlashtirish orqali talabalar dunyoqarashini kengaytirgan. Ushbu tadqiqot nafaqat xitoylik pianino musiqasining madaniy mazmunini tushunish uchun estetik nuqtai nazarni taqdim etadi, balki Xitoy xalq musiqasi an’anaviy estetik g‘oyalarni meros qilib olish va rivojlantirish uchun ta’lim jarayonidagi o‘rnida ham oz o‘rni borligini ochib beradi.

Kalit so‘zlar: *Xitoy musiqasi, fortepiano asarlari, estetik fikr, milliy estetika, an’anaviy estetika, talabalar dunyoqarashi.*

Аннотация. Китайские фортепианные произведения, являясь художественным выражением гармонии китайской и западной музыкальных культур, воплощают в своей творческой практике глубокие традиционные эстетические идеи. В этом исследовании под названием “Исследование традиционной эстетики китайской музыки в фортепианных произведениях” систематически изучаются теоретические истоки традиционных китайских эстетических идей и их практические проявления в создании фортепианной музыки. Исследование показывает, что китайские фортепианные произведения не только сохранили эстетические особенности китайской музыкальной культуры, но и расширили мировоззрение учащихся, сочетая традиционные эстетические идеи с современными творческими стилями. Это исследование не только даёт эстетическую перспективу для понимания культурного содержания китайской фортепианной музыки, но и показывает, что китайская народная музыка играет небольшую роль в образовательном процессе, наследуя и развивая традиционные эстетические идеи.

Ключевые слова: *китайская музыка, фортепианные произведения, эстетическая мысль, национальная эстетика, традиционная эстетика, мировоззрение учащихся.*

Abstract. As the artistic crystallization of the fusion of Chinese and Western music culture, Chinese piano works contain profound traditional aesthetic ideas in their creative practice. This study, entitled "The Study of Traditional Aesthetics of Chinese Music in Piano Works," systematically explores the theoretical origins and practical manifestations of Chinese traditional aesthetic ideas in piano music creation. The study shows that Chinese piano works have not only maintained the aesthetic characteristics of Chinese music culture but also expanded the students' outlook by integrating traditional aesthetic ideas with modern creative techniques. This study not only provides an aesthetic perspective for understanding the cultural connotation of Chinese piano music, but also provides educational inspiration for how Chinese folk music can inherit and develop traditional aesthetic ideas.

Keywords: *Chinese music, piano works, aesthetic thought, national aesthetics, traditional aesthetics, students outlook.*

Introduction

Since the piano art was introduced into China, it has undergone a creative transformation process from technology transplantation to cultural integration [1-3]. The traditional aesthetic ideas contained in it constitute the unique cultural character of Chinese piano music. This study takes the traditional Chinese aesthetic ideas as the theoretical framework, focuses on the three core categories of "harmony beauty," "artistic conception beauty," and "spiritual beauty," and explores its theoretical origins and practical expressions in piano music creation [1, 4, 5]. The significance of the study lies in: on the one hand, by combing the Chinese music aesthetic tradition, it reveals the cultural adaptation mechanism of the piano, a Western musical instrument, in the process of localization; on the other hand, it analyzes the aesthetic practice in specific works and provides a new theoretical perspective for understanding Chinese piano music culture. In terms of research methods, this paper adopts a combination of theoretical analysis and work interpretation [6]. In the first chapter, the connotation of the three major aesthetic ideas and their musical expression characteristics are systematically explained. In the second chapter, representative piano works are selected to analyze the modern expression of traditional aesthetic ideas from the three dimensions of work expression, creative conception, and structural organization. Through this study, we can not only deepen the understanding of the cultural characteristics of Chinese piano music, but also provide a practical reference for how to creatively transform traditional aesthetic resources in Chinese folk music creation.

Analysis and Results

As an important part of Chinese traditional culture, Chinese traditional aesthetics has collided and merged with Chinese traditional culture since the piano was introduced to China from the West, and gradually formed a musical aesthetics different from that of Western piano. Although the piano is an imported product, the cultural core of Chinese-style piano music is national. The creation of Chinese piano music was produced under the influence of Chinese traditional culture and was influenced by traditional aesthetics and aesthetic forms. Its performance will inevitably reflect the national spirit and national character in Chinese traditional art and culture. "Harmony," "artistic

conception," and "spirit" as the essence of Chinese traditional aesthetic thought have become a spiritual connotation, rooted in the creation and performance of Chinese piano works. To correctly interpret Chinese piano works, we must first understand the traditional aesthetic thought and spirit contained in Chinese music [1].

The beauty of harmony. In the Confucian classic "The Doctrine of the Mean," "harmony" is both a moral standard for human cultivation and an aesthetic form of traditional Chinese aesthetics. Harmony means "harmony." "Zhong" is the foundation of stability in the world, and "he" is the way of dealing with people. Only by achieving the unity of "zhong" and "he" can we achieve the state of unity between man and nature and realize the beauty of harmony. As one of the basic aesthetic forms of traditional Chinese aesthetics, the Confucian aesthetic thought of harmony has had a huge impact on my country's traditional culture and art. "The beauty of harmony emphasizes the beauty of moderation that is implicit, moderate and harmonious," and Confucius's "joy without lewdness, sorrow without sadness" is exactly the embodiment of the beauty of harmony. The beauty of harmony advocates restrained, rather than overly strong, emotional expression. This is a poetic spirit and an artistic aesthetic realm of noble virtue [2].

The beauty of artistic conception. "Artistic conception" generally refers to the mood and realm expressed in literary, artistic (calligraphy, painting, music, etc.) works or natural scenes, and also refers to the poetic space of "blending emotions and scenes," and "coexistence of virtuality and reality" presented in lyrical works. "Artistic conception" originated from the ancient Chinese Laozi and Zhuangzi thought and is an important category in traditional Chinese aesthetics. The fusion of emotions and scenes is a lyrical expression realm pursued by the Chinese literati, and it is a kind of cultural cultivation that implies the meaning beyond words. For pianists, they must have a deep cultural accumulation of classical literature, art and national customs as a foundation. "Coexistence of virtuality and reality" in Chinese classical aesthetics originated from "Laozi's coexistence of existence and non-existence thought." "Coexistence of virtuality and reality" believes that all things in the universe and aesthetic activities are the harmonious unity of virtuality and reality. It does not pursue meticulousness and exhaustiveness, but only pursues the emptiness of artistic conception. It is an implicit artistic creation method. Chinese music pursues "emptiness" and "spirit" in sound, and "coexistence of virtuality and reality" is a unique aesthetic pursuit of traditional Chinese music that is different from Western music. The beauty of "artistic conception" also concentrates on the spiritual connotation and unique aesthetic pursuit of traditional Chinese aesthetics.

The beauty of spirit and charm. "Spirit and charm" is a very important concept in traditional Chinese aesthetic culture. Writers and artists of all generations have taken spirit and charm as the goal of artistic creation and the pursuit of a realm. The aesthetic standard of Chinese instrumental performance is "inner heart, outer instrument." "Spirit" is also the inner life of music, giving the inner pulse of music style, and "Rhyme" is the external feature of music's artistic conception, giving music external meaning. The essence of Chinese piano music is alive because of "Spirit" and beautiful because of "Rhyme." "Spirit and charm" is the charm and style contained in the work itself, the inner temperament of music, and the soul of Chinese music [3].

Aesthetics in Chinese piano works

The performance of the piano work “Yangguan Sandie” adapted from the ancient guqin music is the best interpretation of the beauty of harmony. “Yangguan Sandie” has a beautiful artistic conception, sad but not sad, and the melody is simple, quiet, peaceful and natural. It expresses the author's deep farewell feelings when parting with friends, and shows the simple, concise, implicit, and detached noble sentiments of ancient literati. In 1978, Mr. Li Yinghai changed it into a piano piece of the same name, retaining the basic structure of the guqin piece “Sandie”, borrowing and imitating the techniques and timbre of “pressing notes,” “scattered notes,” and “overtones” in the guqin, and expressing the profound artistic conception of the guqin music with the melody of the piano. When playing “Yangguan Sandie,” one should maintain inner peace and tranquility, use soft, delicate and sophisticated touch keys to achieve a full and soft sound, pay attention to the transparency of the sound, and express the guqin’s urgent but not impatient, slow but not empty timbre and temperament calmly and elegantly. When playing, it is necessary to maintain a singing melody line, pay attention to the direction and ups and downs between notes, maintain the continuity of breath, naturally transmit the power to the arms to the fingertips, use the fingertips as much as possible to play deep, peaceful, beautiful, and simple tones, and carefully handle the accompaniment texture according to the performance needs of the music, grasp the level of the voice part, maintain the balance of the music, give hints in implicitness, so as to achieve the complete unity of the music, that is, the “beauty of neutralization,” thereby expressing the deep affection of the ancients when they were reluctant to part.

The piano piece “Erquan Yingyue” is adapted by Chu Wanghua, a famous Chinese composer and pianist, based on Abing’s erhu piece of the same name. While fully retaining the original song's ideological content and style, the work is given a new interpretation. The work leads the audience into the artistic conception of clear springs and cold nights, which evokes emotions and expresses the author’s complex emotions of inner sorrow. This work is a true portrayal of Abing’s life. From the sad and beautiful melody, people can feel his deep pain, sadness, resentment, and grief. It is a summary and condensation of his miserable life [4]. The introduction “Jianggu Bell Tower” of the Chinese piano piece “Sunset Xiaogu” adapted by Li Yinghai uses the unique free beat of Chinese music. There are no strict requirements for beats, bar lines, and speed. Even the number of notes imitating drum sounds is relatively free. The use of superimposed chords of the second and fourth degrees, through the cross-use of two forms of broken chords played successively and block chords sounded simultaneously, makes the sound seem to flow out of the melody, highlighting the flowing and harmonious beauty of the music; in the use of appoggiatura, the appoggiatura of the octave interval is used ingeniously to imitate the timbre of the flute. Many Chinese piano music, through different touches and changes in timbre, creates the beauty of artistic conception in the traditional Chinese aesthetics of “clear, light, ancient and elegant,” and pursues the ethereal and hazy “emptiness” in sound and timbre, achieving the sense of emptiness and tranquility in the artistic conception of the music, to express the profound artistic conception of spaciousness and tranquility.

In the piano work “Sunset Xiaogu,” there are signs of slowing down or free extension at the end of many sections. The slowing down and free extension at this time do not

mean the stillness or end of the music, but require the performer to use the breath to run through each section. The slowing down and extension before the new section also give the performer and the audience a space for reverie and aftertaste. According to the changes in emotions, the needs of the music content, and the specific characteristics of piano performance, the music draws on some structural features of traditional Chinese music and Western music, and simplifies the structure to a certain extent. The piano piece adopts the traditional Chinese multi-section development and repetitive variation techniques to form a relatively free and smooth variation structure. From the perspective of speed layout, it is more consistent with the typical characteristics of Chinese traditional instrumental music "scattered-slow-medium-fast-scattered." After the adaptation, the piano piece has a total of ten sections: introduction, theme, seven variations, and coda. This piano piece, with its unique Chinese characteristics and continuous structure like a trickling stream, makes the music appear before us like an extremely elegant ink painting, without any intention of publicity or venting, fully reflecting the aesthetic taste of the Chinese traditional aesthetic thought of pursuing moderation, moderation, nature and flow [5].

The aesthetic culture in Chinese piano works is rooted in the fertile soil of national traditional culture. The essence of traditional aesthetics has injected unique cultural charm and artistic connotation into Chinese piano works. Performers should not only have proficient piano playing skills, but also have profound traditional cultural cultivation, understand the aesthetic concepts of Chinese traditional culture, and deeply understand the breadth and depth of Chinese traditional aesthetics, so as to accurately interpret the cultural heritage and musical connotation of Chinese piano works [6].

Conclusion

As a model of the fusion of Eastern and Western art, the development of Chinese piano music is not only a history of technical exploration of the localization of Western musical instruments, but also a history of modern expression of traditional Chinese aesthetic ideas. This study takes the three traditional aesthetic categories of "beauty of harmony," "beauty of artistic conception," and "beauty of spirit" as the theoretical framework, systematically examines the creative transformation of Chinese music aesthetic ideas in piano works, and reveals the unique cultural character and aesthetic value of this art form.

At the level of creative concept, Chinese piano works show the contemporary interpretation of traditional aesthetic ideas. Composers have developed the concept of "harmony" into a methodology for cultural dialogue; while maintaining the essence of piano art, they have successfully integrated the essence of Chinese musical language. This fusion is not a simple superposition of elements, but an organic unity achieved through deep artistic processing, such as musical grammar and sound organization. In terms of "artistic conception" creation, modern composers break through the limitations of traditional expression methods, combine the aesthetic experience of contemporary people, and create musical artistic conceptions that are both traditional and modern. Especially in abstract music creation, traditional artistic conception aesthetics has been expressed more innovatively.

From the perspective of music morphology, the modern expression of the "spirit and charm" aesthetics is particularly worthy of attention. Research has found that the spirit and charm in Chinese piano works are not only reflected in the flow of melody lines, but also permeate into musical elements such as harmony and rhythm organization. Some modern works have expanded the expression dimension of the spirit and charm aesthetics through non-traditional performance techniques and sound combinations, making it able to adapt to more diverse musical expression needs. This innovation not only maintains the essence of traditional Chinese art but also gives it new contemporary connotations.

The theoretical contribution of this study is mainly reflected in three aspects: first, it constructs a theoretical framework for the aesthetics of Chinese piano music, providing a systematic analytical tool for related research; second, it reveals the internal mechanism of the modern transformation of traditional aesthetics, providing a model for the innovative development of traditional culture; third, it proposes the aesthetic principles of cross-cultural music creation, which is inspiring for music creation in the context of globalization. At the practical level, these research results can provide theoretical guidance for piano creation, performance, and teaching, and help artists to more deeply understand and express the aesthetic characteristics of Chinese piano music.

Looking to the future, the development of Chinese piano music still needs to continue to explore the following aspects: first, further explore the modern expression of traditional aesthetic ideas, and achieve artistic innovation while maintaining cultural roots; second, strengthen the interaction between theory and practice, so that aesthetic research can better guide creative practice; third, more actively spread the aesthetic concept of Chinese piano music and promote cross-cultural music dialogue. Through continuous theoretical research and artistic practice, Chinese piano music will surely make a unique contribution to the diverse development of world music culture. The successful experience of this art form also tells us that the creative transformation and innovative development of tradition is an important path to building cultural confidence.

References:

[1] Zong Baihua "Aesthetics and Artistic Conception," Beijing: *People's Publishing House*, 2009.

[2] Zhang Lingyu "The Great Beauty of Zhonghe," *J. Drama Home*, 14, 2016, pp. 13-21.

[3] Li Tiantian "Zhonghe, Artistic Conception and Spiritual Charm," - A Brief Analysis of Traditional Aesthetic Thoughts in Chinese Piano Performance Art *Journal of Xinyang Normal University* (Philosophy and Social Sciences Edition), 36, 2016, pp. 96-99.

[4] Hao Lulu "On the aesthetic connotation and performance of Chinese piano works from an aesthetic perspective - taking the piano piece Erquan Yingyue as an example," *J. Northern Music*, 38(12), 2018, p. 102.

[5] Sun Xiao "Research on the aesthetic implications and characteristics of Chinese piano music creation," *Journal of Heihe University*. 15 (03), 2024, pp. 163-166.

[6] Ge Yanqiu "On the development and characteristics of nationality in Chinese piano music," *Journal of Beijing Institute of Graphic Communication*, 12, 2017, pp. 124-126.

UDC: 391(575.1) (035.3)

SECOND RENAISSANCE (FROM TIMURID TO 20TH CENTURY)

Umida Saydazimovna Rakhmatullaeva
Professor, Department of Fashion and Design, Tashkent Institute of textile and Light Industry
uraxmatullayeva@mail.ru

Xolida Hafizovna Kamilova
Professor, Department of Fashion and Design, Tashkent Institute of textile and Light Industry
fashion.uz2019@gmail.com

Komila Baxodir Mirziyodova
Doctoral Student, Tashkent Institute of textile and Light Industry
komilamirziyod@gmail.com

Annotatsiya. Ushbu maqolada ikkinchi Renessans davri Temuriylar davridan XX asrgacha bo‘lgan davrda ayollarning ustki kiyimi joma, koba, faradji, kurta, piroxan kabi turli kiyim-kechaklarining tuzilishi va rivojlanishi bo‘yicha fikr va mulohazalar mavjud.

Kalit so‘zlar: *libos, joma, koba, faradji, kurta, piroxan, kostyum, zebigardon, tumor, zirak, baldoq, uzuk, bilakuzuk, amaliy san’at.*

Аннотация. эта статья содержит мысли и размышления о структуре и развитии различных женских верхних предметов одежды, таких как Джома, Коба, фараджи, Курта, пирохан, со времен Тимуридов второго Возрождения до двадцатого века.

Ключевые слова: *платье, Джома, Коба, Фараджи, Курта, пирохан, костюм, зебигардон, амулет, серьга, обручальное кольцо, кольцо, браслет, прикладное искусство.*

Abstract. this article contains feedback and reflections on the structure and development of various clothing items of women's overalls from the Timurid period of the Second Renaissance to the 20th century, such as the joma, koba, faradji, kurta, pirohan.

Keywords: *dress, joma, koba, faradji, kurta, pirohan, suit, zebigardon, amulet, zirak, baldak, ring, bracelet, Applied Arts.*

Introduction

Suit in Central Asia (Timurid era). The Timurid dress culture dates back to the Second Renaissance. This period is cited in history as the most prosperous in the direction of Art, Applied Art. The costumes of this period are recorded in written sources that the costumes of the court of Achilles were sewn at all costs, giving excellent artistic decoration. Looking back at the history of Saroyamulkhani, she was the wife of Amir Temur. Saraymulkhani, a descendant of Khan, is considered to be the greatest of all the princesses in the harem and achieves the title of “great lady” or “Bibikhonim”.

Bibikhonim's real name is Saraymulkhonim, which means that in the future, my daughter will be the property of a palace. There have been many legends about the girl's khusnu-jamoli. Also, her beauty was sung by poets of the time, such as "if we want to describe her Husn-Jamal in words, you can be helpless and sinned, words capable of describing the anecdote of a zero girl are absent from the world," says Khurshid Davron.

Literature Review

According to the information provided in written sources, during this period, there was a great emphasis on dress culture, zebu-ornament, and humanity. It is customary for Palace women to wear fancy clothes, such as Palace axles, and such dresses are made of expensive fabrics [1].

In particular, according to miniature images, the names, types, shape, physique, and decoration of the women's costume in the second half of the XIV-early XV centuries were similar to those of men. The uniform of the time consisted of overalls and undershirts, and overshirts and undershirts. The undergarment was a white shirt "kurta" with a tunic-like wrist, long sleeves.

Its collar shaft is horizontal, deeply vertical, or deeply triangular, with a slightly curved waist and buttoned to large buttons. It was the back and side seams of the shirt, and over the undershirt, a different coloured, tunic-like wrist shirt "pirohan" was worn. The pyrochane is long or short-sleeved, with a length from the undercoat to the knee, and is attached to the waist. A *ishton* "ezor" was used as the inner waistcoat. This easel is up to tall and is sometimes tucked into boots or *mahsis*.

Women's outerwear consisted of *joma, koba, faradji* as well as a bitch. One of the clothes to be worn over dresses, the one that received open, with long or short sleeves, used a Koba. And on ceremonial occasions, a bashang Chopan faradji with very long sleeves, made of silk or kimkhob, up to the ground in length, was worn.

Also used as a top was the short, pre-open, long or short-sleeved dress "bitch". The lining of Koba, *joma, faradji* and *kaltacha* is made of another color of silk fabric. The lining of the *faradji* is made of almakhon, Fox, and otter fur. Expensive fabrics were used to sew the clothes of the ladies of the palace. [2]

It has also been a tradition for women to wear several garments over the bar. As a street dress, women used a cloak. It was made of a wide, rectangular fabric that covered the body. It is known that by this period, the influence of Indian, Mongolian, Iranian, and Chinese clothing on women's clothing is felt. In particular, it can be seen in the fabrics and decorations used in the costumes of court morality. Palace women, including Saroymulkhani, used dresses from this beach.

Ruyi González de Clavijo recorded in his memoirs. The Lady of the Palace estate was dressed like this: a long and wide, sleeveless and collar-less red royal dress with gilded decoration on the shoulder, with a skirt that extended to the skirt without any cut and narrowing from the waist. For the Queen to walk easily, the skirt of the jacket was carried by about fifteen women. The Queen's face was covered with a thin white cloth, with a pointed red headdress on her head, similar to the helmet worn in battle.

Research Methodology

Its poplars are resting on the lady's shoulder, with fabric sewn into the lower part. Many *durri* noblemen, rubies, *feruzas* and other different (precious) stones are very beautifully placed on them. The part of the headdress embroidered with gilding and falling on the lady's shoulder is also decorated with precious stones and *durri* unique gold leaf. The tip of the cap also looks like a *bamisoli jajji* awning, extraordinarily beautiful, with a *yal-yal* lit in two finger coloring, with a clear set of three rubies. [3]

It was also mounted on it, with the length of two old white shells with some feathers bent down, some falling into the face and eyes. The brim at the end of the veil, rich in DICE threads, is lined with (precious) stones, pearls, and flickers when walking. A few women hold on with their hands so that the red cap on the lady's head does not fall off.

According to the Spanish ambassador, Palace women dressed a little *bashang* for celebrations and ceremonies. In it, mainly, the headdress was given more attention. The headdresses of the ladies of the Palace looked like a red headdress with a helmet-like tip. The reason for such headdresses to be a tradition is that it is known that during the Timurid era, crafts were developed for some time, and trade became much more extensive.

Analysis and Results

Central Asia had trade and diplomatic relations with many countries. In turn, large-scale trade caravans from neighboring India, Iran, Balkh, Russia and other countries came to this land. During this period, like the Western Renaissance, the Renaissance was observed on every aspect of Central Asia. In our opinion, the influence of the Gothic style can also be observed in dresses. This was mainly manifested in women's dresses. Examples of this are high-pointed hats, pleated dresses at the waist, scarf tops, velvet fabrics, and patterned dresses with the image of plants. But the miniatures show that women also had a scarf as their headdress, caps with fur decorated at the edge, foreheads and crowns. Such headdresses were used mainly in everyday life. A scarf is wrapped over the forehead.

A special place in a woman's costume is occupied by attention to jewelry. In particular, jewelry, mostly from under the upper garment, used *zebigardon*, amulets, earrings, *baldocks*, rings, bracelets, and springs. These ornaments are made of precious metals such as gold, silver, which are decorated with rare stones such as rubies, pearls. This, in turn, gave women the status of court, while giving them beauty. It has been a tradition for court ladies, including Emir consorts, to all wear these robes.[4]

And as shoes, leather *chakme*, *nim chakme*, *makhsi*, and *kavush* were used. The shoes came in black, white or yellow colors.

Conclusion

The robes of Saroymulkhani were embroidered for celebrations and celebrations and for the day, giving a special appearance. For dresses, expensive fabrics brought from abroad were used. In particular, it is customary for women to wear several garments over and over during ceremonies, while white cotton fiber cloth was used for underwear, red silk was worn for the upper garment, and Red Velvet was worn over it. In the decoration of the top, vegetative patterns stylized on the shoulders and front parts are sewn using the serum technique. The upper garment had a short sleeve, and the undergarment had a prominent sleeve. The insides and tops are in a tunic-like wrist,

extended towards the skirt in a long, non-body-attached position. The underwear was packaged with large buttons. [5]

A pointed red headdress was worn as the headdress. Under him, a white cloth fell on the chariot, covering the face of women. The hoods on the headdress are decorated with precious stones on the floor that fall on the shoulders of women. Three ruby stones, each two centimeters in diameter, are installed at the tip of the headdress, as well as a length decorated with two old white brow feathers. There is also a goblet on the shoulder part of the bargak women, decorated with precious stones.

References:

[1] Rakhmatullaeva U.S., Mirfayazova N., Xoliqov K., Toshpulatov S., Nazarov A. "Traditional uzbek embroidery history and analyses of their symbolic meanings," *Journal of Scientific and Technical Institute of Namangan Institute of Engineering Technology*, 2019.

[2] Rakhmatullaeva U.S., Turapova M.F. "Types of felting technique and its use in modern clothes," *Internetional Conference on Humanities, Education and Science*. Californiya USA Conference, 2022.

[3] Rakhmatullaeva U.S. "Clothing culture of Uzbek people: traditional and modern clothes," (philosophical and cultural approach) dis. Tashkent, 2010.

[4] Kamilova H.H., Rakhimova Z.I., Rakhmatullaeva U.S. "National Uzbek clothes and traditional values," Monograph. *G.Gulyam publishing and printing house*. Tashkent: 2018, p. 330.

[5] Kamilova H., Rahimova Z., Muminova U., Rakhmatullayeva U. "Traditional Uzbek costumes based on materials from museums and private collections of Uzbekistan," Book-album. Part 1. Prepared on the basis of *"Zamon-Press-Info Publishing House"* LLC. Publication license AI№ 289, 04.11.2016. "Silk Road Media" LLC. ISBN:978-9943-7500-1-2.

UDC: 308, 316, 316.4

PUBLIC CONTROL AS A FORM OF SOCIAL CONSCIOUSNESS: PHILOSOPHICAL FOUNDATIONS OF CIVIL ACTIVISM AND SOCIAL RESPONSIBILITY

Babajanov Sarvarbek Bekpulatovich
Acting Associate Professor, Urgench Innovation University
sarvarbekbabajonov@urgiu.uz

Annotatsiya. Maqolada jamoatchilik nazoratining ijtimoiy ong shakli sifatida ahamiyati va fuqarolik faolligi hamda ijtimoiy mas'uliyatning falsafiy asoslari tahlil qilinadi. Shuningdek, G'arb va O'zbekiston kontekstida jamoatchilik nazoratining rivojlanishi falsafiy yondashuv asosida yoritilib, jamoatchilik nazorati faqat tashqi nazorat vositasi bo'lib qolmay, balki jamiyatdagi o'zgarishlarga ta'sir ko'rsatish va fuqarolik ongini faollashtirish jarayoni ekanligi tizimli ravishda asoslab berilgan.

Kalit so'zlar: *Jamoatchilik nazorati, fuqarolik faolligi, ijtimoiy ong, ijtimoiy mas'uliyat, tanqidiy fikrlash, demokratiya, fuqarolik jamiyati, ijtimoiy adolat.*

Аннотация. В статье анализируется значение общественного контроля как формы социального сознания, а также философские основы гражданской активности и социальной ответственности. Кроме того, развитие общественного контроля в контекстах Запада и Узбекистана рассматривается через философский подход. В статье доказано, что общественный контроль является не только внешним механизмом контроля, но и процессом, который влияет на социальные изменения и активирует гражданское сознание.

Ключевые слова: *Общественный контроль, гражданская активность, социальное сознание, социальная ответственность, критическое мышление, демократия, гражданское общество, социальная справедливость.*

Abstract. This article analyzes the significance of public oversight as a form of social consciousness, alongside the philosophical foundations of civic activism and social responsibility. Furthermore, the development of public oversight in the contexts of the West and Uzbekistan is examined through a philosophical approach. The article demonstrates that public oversight is not merely an external control mechanism, but a process that influences societal changes and activates civic consciousness.

Keywords: *Public oversight, civic activism, social consciousness, social responsibility, critical thinking, democracy, civil society, social justice.*

Introduction

Public oversight emerges as a practical expression of social participation, civic activism, and public monitoring of governance processes in modern democratic societies. In its essence, it is not only an organizational-legal form of control but also manifests as the conscious, critical, and responsible attitude of society's members towards the state and social institutions. Therefore, the phenomenon of public oversight requires a philosophical analysis as a form of social consciousness.

Literature Review

As a philosophical category, social consciousness is the process by which individuals comprehend social life, existing socio-political relations, and the structure of society, evaluate them, and shape their position towards them. According to Hegel, "Social consciousness is the spirit's objective connection with reality, striving for self-realization in historical development" (Hegel, 1990). Public oversight represents the active and critical stage of this process, as through it, the citizen realizes their social position, seeks to strengthen it, and becomes an active subject within the existing social system.

In this sense, public oversight is activated social consciousness, that is, the realization by citizens of their place in the social environment, and the manifestation of this conscious realization through specific actions. As expressed in Habermas' "Theory of Communicative Action," "genuine participation in social life is achieved through striving for agreement based on communicative rationality" (Habermas, 1984).

From this perspective, it can be said that public oversight is not merely observation, but an active communicative act aimed at engaging with social and political systems, evaluating them, and suggesting alternative directions.

Moreover, Foucault interprets social control not just as a repressive or sanctioning mechanism, but as an expression of social knowledge and power relations: “Control is a form of alternative power that not only distributes force but also shapes social consciousness and critical thinking” (Foucault, 1977). Therefore, public oversight is not only a relationship between citizens and external institutions, but also an internal process aimed at self-realization, self-regulation, and strengthening moral positions.

The Law of the Republic of Uzbekistan “On Public Oversight” (2018) defines citizens' right to oversee the activities of state authorities, local self-government bodies, and other organizations. However, the key condition for the effectiveness of these oversight mechanisms is the high level of social consciousness among citizens, which is closely linked to their civic identity, sense of moral responsibility, and critical thinking skills. Thus, by studying the phenomenon of public oversight as a form of social consciousness, we can gain a deeper understanding of the philosophical foundations of social activism, the mechanisms of civic consciousness formation, and the role of ethical development in societal progress. This approach allows us to interpret public oversight not just as a technical tool, but as a social-philosophical process, with social consciousness defined as “the way society members consciously perceive and actively relate to existing reality” (Karimov, 2021). Public oversight is the practical manifestation of this consciousness, meaning it is a form of citizens’ direct participation in state and societal life.

Research Methodology

The research utilizes a philosophical-comparative method, conceptual analysis, and a social constructivist approach. The analysis compares the views of thinkers such as Plato, Hegel, Habermas, and Fromm on social consciousness, social responsibility, and civil society with contemporary forms of oversight. Additionally, national practices are analyzed based on the Law of the Republic of Uzbekistan “On Public Oversight” (2018). Content analysis methods are also applied using internet resources, official reports, and scientific articles.

Analysis and Results

The analysis reveals that public oversight, when deeply analyzed for its social essence, serves to form a critical attitude and reflective thinking system in relation to the socio-economic and political changes in society. This phenomenon is interpreted in Western social philosophy through the concept of “critical consciousness.” Brazilian educator and philosopher Paulo Freire explains this concept as: “Critical consciousness is the human’s conscious understanding of social reality and its transformation into an active movement of thought” (Freire, Pedagogy of the Oppressed, 1970).

Erich Fromm emphasizes that as humanity strives for freedom, it inevitably takes on responsibility: “Freedom is not just the possibility of choice, but the obligation to respond to the consequences of that choice” (Fromm, The Sane Society, 1955). From this perspective, civic activism is the objective manifestation of subjective freedom

through social responsibility, meaning that citizens act not just from rights but from an ethical standpoint.

Social-philosophical analyses conducted in the context of Uzbekistan show that the "On Public Oversight" Law, adopted in 2018, has certainly created an institutional-legal foundation. However, the critical activism level of social consciousness has not yet sufficiently formed. Among certain segments of the population, passive, deterministic forms of consciousness, such as "my opinion won't change anything" and "the state will do as it pleases," still prevail. This situation reflects social indifference and a lack of trust in social institutions, which slows the process of forming reflective, responsive civic subjectivity in society.

Philosophically, this passivity indicates the weak level of social legitimacy and communicative participation in society. As Habermas emphasized, "The strength of civil society is not just in information exchange but in communication based on mutual understanding and consensus transformed into action" (Habermas, Theory of Communicative Action, 1984). Thus, to develop public oversight institutions, it is essential to foster a culture of critical thinking, social responsibility, and ethical commitment to social justice within social consciousness.

Western philosophical thought, especially the "Theory of Communicative Action" developed by Jürgen Habermas, interprets active civic participation and the ability to engage in open communication with the state as a constitutive element of democratic social systems. In Habermas' theory, communication is not just about exchanging information, but is an epistemic process aimed at defining social realities through communicative rationality. As he stated, "The pursuit of truth is determined through open and reasoned communication among individuals" (Habermas, The Theory of Communicative Action, 1984). This concept establishes the participation of citizens in state politics not merely as an external oversight mechanism but as a social reflection and conscious responsibility act.

In Uzbekistan, these communicative practices and civic participation processes are still developing. While legal frameworks for public oversight have been established in recent years, the internal (ontological and axiological) aspects of this process have not yet been fully developed. From a philosophical perspective, public oversight serves as an indicator to measure the ethical maturity of society, the culture of critical thinking, social trust, and the level of responsible subjectivity. This enables us to view it not merely as a governance mechanism but as a communicative, ethical, and axiological expression of social consciousness.

The dialectical relationship between social consciousness and responsibility, especially in post-totalitarian societies, is essential for the formation of civil society. Social consciousness is not just subjective perception but a complex psychosocial system formed based on social experience, information, values, and historical memory. Responsibility within it, as Fromm emphasized, arises as an ethical consequence of freedom (Fromm, The Sane Society, 1955).

In our country, effective implementation of public oversight depends on social institutions, including the education system, mass media, culture and arts, neighborhoods, and civil society associations. In particular, the education system plays a crucial role in shaping critical thinking, social responsibility, reflective

consciousness, and activism. The media creates the information flow that stimulates public consciousness and forms the field of mass discourse.

Conclusion

Public oversight is not just a tool of the governance system but a process closely related to changes in citizens' social consciousness, moral development, and the growth of a sense of responsibility. It is realized through civic activism, personal positioning, and the understanding of freedom.

While the institutional foundations of public oversight are being strengthened in Uzbekistan, its social-philosophical and cultural-responsibility interpretation has not yet been fully developed. This requires the improvement of critical consciousness levels among citizens, the activation of their moral positions, and most importantly, the establishment of a humanized communication culture between the state and civil society. For the development of public oversight in Uzbekistan: Philosophical-educational programs to activate citizens' consciousness should be implemented, and the environment that shapes social consciousness-education, mass media, the internet, and culture-should be strengthened.

References:

[1] Freire P. "Pedagogy of the Oppressed," New York: *Herder and Herder*, 1970.
[2] Fromm E. "The Sane Society," New York: *Rinehart and Company*, 1955.
[3] Habermas J. "The Theory of Communicative Action," Reason and the Rationalization of Society. Boston: *Beacon Press*. Vol. 1, 1984.
[4] Berger P., and Luckmann T. "The Social Construction of Reality: A Treatise in the Sociology of Knowledge," New York: *Anchor Books*, 1966.
[5] Blumer H. "Symbolic Interactionism: Perspective and Method," Englewood Cliffs: *Prentice-Hall*, 1969.
[6] O'zbekiston Respublikasi "Jamoatchilik nazorati to'g'risida"gi Qonuni. Qabul qilingan sana: 12.04.2018. https://lex.uz
[7] Arendt H. "The human condition," *University of Chicago Press*, 1958.
[8] Dewey J. "The public and its problems," *Henry Holt & Co*., 1927.
[9] Giddens A. "The constitution of society: Outline of the theory of structuration," *University of California Press*, 1984.
[10] Rawls J. "A theory of justice," *Harvard University Press*, 1971.
[11] Sen A. "Development as freedom," *Oxford University Press*, 1999.
[12] Ilkhamov A. "Neopatrimonialism, interest groups, and patronage networks: The impasses of the governance system in Uzbekistan," *Central Asian Survey, 26*(1), 2007, pp. 65-84.
[13] Luong P.J. "Institutional change and political continuity in post-Soviet Central Asia: Power, perceptions, and pacts," *Cambridge University Press*, 2002.
[14] Matveeva A. "Legitimising Central Asian authoritarianism: Political manipulation and symbolic power," *Europe-Asia Studies*, 61 (7), 2009, pp. 1095-1121.
[15] Fox J. "The uncertain relationship between transparency and accountability," *Development in Practice, 17*(4-5), 2007, pp. 663-671.
[16] Goetz A.M., & Jenkins R. "Reinventing accountability: Making democracy work for human development," *Palgrave Macmillan*, 2005.

UDC: 908, 930.2

HISTORICAL ANALYSIS OF THE INVOLVEMENT OF THE PUBLIC EDUCATION SYSTEM IN AGRICULTURAL WORK IN THE 60s OF THE 20TH CENTURY (USING THE EXAMPLE OF THE SAMARKAND REGION)

Sharipova Nargizakhon Abdukakhorovna
Associate Professor, Doctor of Philosophy in Historical Sciences, Kokand State University
nar.kokand@gmail.com

Annotatsiya. Ta’limning vazifasi kelajak avlodga saboq berish, o‘quvchilarni qiziqishlari bo‘yicha oliy ta’limga yo‘naltirish va to‘g‘ri tarbiya berishdan iborat. Ammo tarixda shunday davr bo‘ldiki, O‘zbekiston zimmasiga yuklatilgan paxta rejasi, aholining barcha qatlamini qamrab olib, ta’lim vakillari ham qishloq xo‘jaligining noqonuniy a’zosiga aylantirildi. Maqolada davriy nashr, arxiv materiallari asosida ta’lim tizimini qishloq xo‘jalik ishlariga jalb qilinishining tarixiy aspektlari haqida so‘z yuritildi.

Kalit so‘zlar: *ministrlik, maktab, mahalliy sovetlar, o‘qituvchi, oila, politexnik yo‘nalish, moddiy-texnik baza.*

Аннотация. Задача образования состоит в обучении будущего поколения, направлении учащихся к высшему образованию в соответствии с их интересами и обеспечении правильного воспитания. Однако в истории был период, когда план по сбору хлопка, возложенный на Узбекистан, охватил все слои населения, и представители сферы образования также были превращены в неправомерных участников сельскохозяйственных работ. В статье рассматриваются исторические аспекты привлечения системы образования к сельскохозяйственным работам на основе материалов периодической печати и архивов.

Ключевые слова: *министерство, школа, местные советы, учитель, семья, политехническое направление, материально-техническая база.*

Abstract. The task of education is to educate the future generation, direct students to higher education according to their interests, and provide proper upbringing. However, there was a period in history when the cotton harvest plan imposed on Uzbekistan encompassed all segments of the population, and education sector representatives were also turned into illegal participants in agricultural work. The article examines the historical aspects of involving the education system in agricultural work based on periodicals and archival materials.

Keywords: *ministry, school, local councils, teacher, family, polytechnic direction, material and technical base.*

Introduction

In Uzbekistan, the practice of forcing the education system to participate in compulsory labor has been prohibited since 2018. Before that, mass mobilization for harvesting cotton, our technical crop, had become widespread. The involvement in all types of agricultural work intensified starting from the 1950s [1]. The introduction of

polytechnic education in schools, the allocation of land for planting and tending crops, and the assignment of upper-grade students to these tasks have made schools completely dependent on cotton. From early spring until late autumn, and in some cases even in December, time was spent in the fields instead of at desks.

Literature Review

There is a wealth of scientific literature available on the history and development of public education during the Soviet era. In particular, the research conducted by authors such as K. Qodirov, S. Sodiqov, S. Shermuhammedov, and S. Mavlyanova provides information on organizing a professional development system for school teachers.

Research Methodology

The article is illuminated based on generally accepted historical methods - the principles of historicity, comparative-logical analysis, sequential approach, and objectivity.

Analysis and Results

An order of the Samarkand Regional Department of Education dated September 28, 1963, was issued to implement Resolution № 555 of the Central Committee of the Communist Party of Uzbekistan and the Council of Ministers of the Uzbek SSR dated September 21, 1963, “On Assisting Collective and State Farms in Harvesting and Delivering the 1963 Cotton Crop to the State.” According to the order, students in grades 5-11 from schools in rural areas and urban-type villages are required to participate in the cotton harvest from October 1st to 30th. This participation is organized as part of their educational and production practice scheduled at the end of the academic year, as specified in the curriculum [2-5]. The cotton picking schedule for students has been approved, broken down by class [6].

School administrators involved in cotton harvesting were obliged to submit reports at meetings held every night. School principals who failed to meet the quota or mobilize sufficient numbers of pickers were punished. According to Order № 124 of the Samarkand Regional Department of Public Education dated October 18, 1963, some district heads of public education departments and school principals had not properly organized participation in the cotton harvest. They did not organize sufficient participation in the cotton harvest. That is, in the Bulungur district, the mobilization of schoolchildren, teachers, and technical personnel amounted to 25 percent, in the Nurata district - 3.6 percent, and in the Samarkand district - 2.4 percent.

Several school principals were reprimanded due to insufficient promotional activities carried out in the cotton fields, the poor organization of wall newspapers and competitions, and the low level of incentives provided to those who picked large amounts of cotton [6].

The director of School № 18 in Bulungur district, Akhunov, failed to give political importance to the cotton campaign and allowed only 115 people to participate instead of the planned 338 students and teachers. As a result, the school principal Akhunov was dismissed from his position [6].

Not only school staff, but also employees of the advanced training institute and teachers who had come for professional development were conscripted into cotton

picking. They were ordered to gather at 8 o'clock every day and take buses to the cotton fields [6].

Conducting educational activities at a school that had been in the field for a long time became problematic. To address this, a plan was devised to intensify the learning process in order to cover the allocated hours in the curricula and catch up on the missed program material [6].

The Ministry of Education of Uzbekistan issued Order № A-292 on November 26, 1963, "On catching up on missed class hours and improving educational work due to the involvement of schools in the republic in agricultural activities". In the order, there was a large difference in the density of classes in urban and rural schools. An attempt was made to further de-educate rural education, which was already fully covered by agricultural work. In particular, it is planned to reduce physical education by 1 hour per week in urban schools in grades 5-8 due to socially useful work practice at the end of the academic year, to increase the weekly hours to 36 hours in schools with Russian as the language of instruction, and to intensify lessons by reducing winter and spring breaks by 6-9 days. In grades 9-10, due to socially useful work practice at the end of the academic year, it is planned to reduce physical education by 1 hour per week, reduce winter and spring holidays by 12 days, reduce production subjects by 3 hours per week, reduce winter and spring holidays by 12 days in grades 11, reduce production subjects by 6 hours per week in schools with Russian as the language of instruction, and reduce production subjects by 5 hours per week in Uzbek. The number of reductions in academic performance in rural schools has increased. In particular, it was determined that winter and spring vacations in grades 5-8 can be reduced by 12 days due to practice at the end of the academic year, due to socially useful lessons, due to the reduction of physical education, due to such subjects as Russian language, foreign language, drawing in Russian schools (if there is no teacher). In grades 9-10, it was planned to reduce winter and spring holidays by 12 days, and due to practice at the end of the academic year - up to 6 weeks, due to socially useful lessons, reducing physical education [6].

Students and teachers of grades 7-10 of the Urgut district picked cotton in the Ishtikhan and Payaryk districts during the 1966 cotton harvest [5]. Handing over 5,100 students to their parents safely and safely carries a great responsibility. To avoid unpleasant situations, the teacher was required to monitor day and night. In the 1960-1961 academic year alone, 74 secondary schools of industrial training were organized in the schools of the Samarkand region. They had 140 9^{th} grades and 35 10^{th} grades. The production line consisted of 36 types. The basis of production were collective farms, state farms, production organizations, workshops, and tractor parks [7].

Order № 17 of the Regional Department of Education dated March 14, 1961, “On Improving Production Training in Samarkand Regional Schools,” was adopted [7]. Such legal documents were adopted almost annually. Based on Resolution № 69 of the Council of Ministers of Uzbekistan dated January 24, 1962, general secondary schools began training cotton harvesters, livestock mechanics, secretaries, cooks, tailors, fitters, and other specialists [6].

In 1963, there were 1055 schools in the Samarkand region, of which 394 were primary, 498 were eight-year, and 159 were secondary schools. 201439 students

studied in these schools. In 159 schools, polytechnic, i.e., production-specialized education was organized, in which 72,367 students studied [6].

As an experiment, 30-40 hectares of land were allocated to rural schools, and cotton was cultivated in early spring under the guidance of teachers. In addition to spring work, such as hoeing and thinning, cocoon harvesting, fruit harvesting, and hay gathering were also carried out in May-July, and until the fulfillment of the cotton delivery plan to the state in December, rural teachers and students were in the cotton fields. The government's policy of developing industrial education in schools, on the one hand, created the basis for students to become specialists in various professions, and on the other hand, contributed to their greater involvement in agriculture and the emergence of cotton growing specialists from school desks.

Production education continued to expand steadily. In the following academic year, the material and technical base of 969 secondary and eight-year schools in the Samarkand region was modified. The following production training subjects were taught in these schools: 472 woodworking workshops; 158 metalworking workshops; 203 general workshops; 194 sewing workshops; 94 general technical cabinets; 686 experimental plots; driver (mechanization) training in 31 schools; household services (hairdressing) in 4 schools; and in one school, classes in typing and office management were organized. Driving (mechanization) in 31 schools; Household services (hairdressing) in 4 schools [4].

In the Jomboy district, a brigade of 11th-grade students produced 115 centners of cotton from 3 hectares. The student brigade of school № 30 in the Akdarya district was awarded 175 rubles for their active participation in agricultural work and their performance in cotton picking [4]. Information was collected on the development of industrial education in schools throughout the republic and the crops grown in them [7-8].

Conclusion

It can be noted that the primary external factor contributing to the decline in the quality of education in Uzbekistan is the involvement of students in agricultural work. This practice, which began as collective labor and a means of fostering social responsibility in students, has led to negative consequences. While the positive aspect might be seen as preparing students for adult life and family responsibilities, it is important to point out the negative side: the specializations introduced in rural schools have been specifically aimed at training students as assistants in agricultural work.

References:

[1] Nargizaxon Sharipova “A look at the history of building schools in Uzbekistan (50-70 years of the 20th century),” *World Bulletin of Social Sciences (WBSS)*. Vol. 26, September 2023, pp. 62-66.
[2] State Archive of Samarkand Region, fund 1820, inventory 1, file 40, sheet 260, sheet 463.
[3] State Archive of Samarkand Region, fund 929, inventory 1, file 44, sheet 47.
[4] State Archive of Samarkand Region, fund 942, inventory 4, file 119, sheet 93, sheet 402.
[5] State Archive of Samarkand Region, fund 942, inventory 4, file 119, sheet 484, sheet 457.
[6] State Archive of Samarkand Region, fund 942, inventory 4, file 119, sheet 462, sheet 464.
[7] State Archive of Samarkand Region, fund 942, inventory 4, file 549, sheet 36, sheet 38.
[8] State Archive of Samarkand Region, fund 942, inventory 4, file 845, sheet 12.

UDC: 37, 37.01, 1, 004.43

USING MODERN METHODS OF TEACHING PROGRAMMING LANGUAGES IN PEDAGOGICAL UNIVERSITIES

Bobomukhamedova Shoira Agzamdjan Kizi
Tashkent State Pedagogical University named after Nizami (PhD) Doctor of Philosophy
shoira_shaki@mail.ru

Annotatsiya. Ta’lim tizimini raqamlashtirish o‘quv maqsadlariga erishishga qaratilgan zamonaviy texnologiyalarning ta’limiy afzalliklarini o‘zida aks ettiradi. Ushbu maqolaning maqsadi pedagogika Oliy ta’lim muassasalarida dasturlash tillarini zamonaviy ta’lim texnologiyalaridan foydalanib o‘qitishga qaratilgan bo‘lib, dasturlash tillarini o‘qitishda talabalarning kognitiv vizual ko‘nikmalarini rivojlantirishga xizmat qiluvchi kouching (coaching) usuli, algoritmik fikrlashga yo‘naltiruvchi bosqichma-bosqich (step by step) usuli hamda ularning motivatsiyasini oshiruvchi geymifikatsiya (gamefication) usullari yoritilgan.

Kalit so‘zlar: *zamonaviy usullar, dasturlash tillari, kouching (coaching) usuli, kognitiv vizual ko‘nikmalar, bosqichma-bosqich (step by step) usuli, algoritmik fikrlash, geymifikatsiya (gamefication) usuli, motivatsiya.*

Аннотация. Цифровизация системы образования отражает образовательные преимущества современных технологий, направленных на достижение образовательных целей. Целью данной статьи является обучение языкам программирования с использованием современных образовательных технологий в педагогических вузах, выделены метод коучинг, служащего развитию когнитивно-визуальных навыков студентов при обучении языкам программирования, пошаговый метод ведущий к алгоритмическому мышлению, а также повышения мотивации обучающихся на основе метода геймификации.

Ключевые слова: *современные методы, языки программирования, метод коучинга (коучинга), когнитивные визуальные навыки, пошаговый (постепенный) метод, алгоритмическое мышление, метод геймификации (геймификации), мотивация.*

Abstract. The digitalization of the education system reflects the educational advantages of modern technologies aimed at achieving educational goals. The purpose of this article is to teach programming languages using modern educational technologies in pedagogical universities, highlighting the coaching method that serves to develop the cognitive-visual skills of students when teaching programming languages, a step-by-step method leading to algorithmic thinking, as well as increasing student motivation based on the gamification method.

Keywords: *modern methods, programming languages, coaching method, cognitive visual skills, step-by-step method, algorithmic thinking, gamification method, motivation.*

Introduction

In the current landscape of global educational institutions, advanced pedagogical approaches and modern information and communication technologies (ICT) are being implemented in teaching practices. Based on the prospects for applying ICT in education outlined in UNESCO's "Education 2030" international forum, systematic efforts are being made to enhance the quality and level of education, develop massive open online courses (MOOCs), and improve ICT structures and platforms that facilitate learning and management [7].

In recent years, our country has been developing national programming schools by increasing competition in the field of digital technologies and establishing regulatory frameworks for the use of modern educational technologies to improve the learning process.

Literature Review

Scientific works on the methodological system of teaching programming languages were studied by such scientists as Ye. Deykstra, T. Cormen [1], M.S. Shapovalova, M.M. Aripov, N.A. Otakhanov, M.Kh. Lutfullayev, Ye.S. Pavlova, O.G. Nelzina, M.A. Pavlichenko [2] and other scientists emphasize that in the context of digitization of education, programming languages should be taught by using modern educational technologies.

According to D. Polcin [3], L. Snajdar [4], and J. Gunislar [4], components of the methodological system of teaching programming languages like new content, forms, and methods play a crucial role in the professional training of future computer science teachers.

In recent years, the development of programming schools based on modern educational technologies has become one of the pressing issues in higher pedagogical education institutions. To address this issue, it is advisable to use modern methods in teaching programming languages.

In students' professional training, it is essential to introduce the content, objectives, forms, methods and tools of programming languages to develop initial skills and competencies.

Nurbekova J.K. proposed several methods for teaching programming languages, including the manual tracing method for programs (algorithms), the method of promoting programs, the programming method, the method for teaching specific sections, the demonstration method for examples, and project-based methods [5].

Research Methodology

We recommend the use of the "coaching" method, which serves to develop the cognitive-visual skills of students in the theoretical classes of the "Programming languages" course. This method is an art that helps students to improve the effectiveness of teaching programming languages, and it is a system of introducing social, personal and creative potential in order to get the maximum effective result.

The “coaching” method is an art that helps students to increase the effectiveness of teaching programming languages, and is a system of introducing social, personal and creative potential in order to obtain the maximum effective result [6].

“Coaching” method is a teaching method in which the teacher helps the student to achieve a specific goal. “Coaching” is to open the potential of the participants to achieve the maximum result. A coach is a specialist, an exercise trainer. Educational coaching demonstrates the ability to grow a successful student. The direct results of “coaching” are the improvement of the performance of each person and the group as a whole, the ability to react quickly and effectively in critical situations, flexibility and adaptability to changes.

The important thing about the “coaching” method is that even low-achieving, shy and timid students can find time to express their opinions, students can familiarize themselves with the problem and prepare before the debate begins.

When learning a new topic, it is determined what and how to learn, what to discuss, what can be left for independent work. After that, draw a circle (on the Jamboard) to draw the balance wheel and divide it into 8-10 equal parts. These sections can be filled with different content (topic learning sections, lesson elements, project steps, etc.).

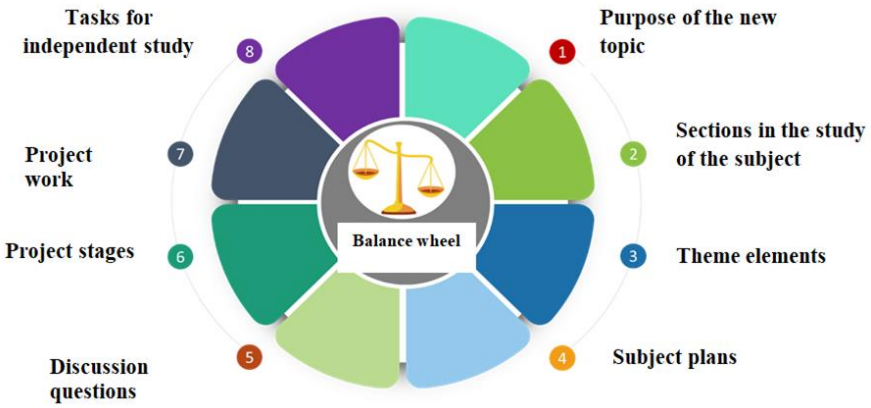

Figure 1. Balance wheel

Project discussions allow students to continue discussing the course after the classroom hour is over. This can be a way for students to integrate the knowledge they have acquired in classroom lectures into online discussions.

The use of the “Step by step” method, consisting of seven steps, in practical exercises conducted in the “Programming Languages” course creates an opportunity to teach students algorithmic thinking in solving problems using programming languages.

The essence of the “Step by step” method is to master the material step by step, and in small groups it is possible to discuss several issues at once. In this case, each member of the group can participate in the discussion of all the proposed issues and make their own contribution.

“Gamification” in the educational process allows for a gradual introduction to the content of subjects taught in higher education institutions [9].

Teaching subjects taught in higher education institutions through the “gamification” method develops students’ skills and competencies such as motivation for self-development, enjoyment of their activities, and collaborative problem solving.

This method requires excellent software, a dynamic learning environment, and teachers with professional knowledge. The “gamification” method uses game elements such as a sequence of tasks, feedback, levels, and creativity. Players accumulate points and scores, which in turn ensures better mastery of the topic and material.

When using the “Gamification” method, we use the Algotica logic game program in the “gamification” method to determine the results of students’ learning and cognitive activities in the “Programming Languages” course [10].

Algotica is an adventure and puzzle game dedicated to learning programming with stories that break the “fourth wall,” a logic game that teaches the basics of algorithmization and programming in an interactive format [8].

A small robot is controlled by programming languages its movements using codes. At each level, the robot occupies a certain number of memory cells. Each cell can contain one command. Commands are entered in the field on the left side of the screen. By pressing the Command key, a new line appears, into which the command is entered. The entered commands are executed using the Run command. After the command is entered, the robot starts moving.

Table 1. Examples of levels to complete in the game Algotica.

Level 1	**Level 2**	**Level 3**
Very easy level. Just enter the forward command and the robot will move to the red teleport.	First, the forward command must be given, so that the robot moves forward, and then backward to return to the red teleport.	At this level, the robot moves forward and then turns according to the Forward command. The entered program is cycled, that is, after the last line, the first one starts executing again. The first one has forward included, so it does not need to be entered again.
		
Level 7	**Level 11**	**Level 15**
There are four panels, which alternately perform turns and forward movement. The robot learns a new command like jump.	At this level, you can choose which path to take. The computer residents will ask you to help them with some difficult task. To do this, you will need to turn right at the first “crossroads”.	The robot has a scanner, and connecting portals appear. Portals of the same color are connected to each other. This task is completed with just one forward command. First, the area is scanned with the X button.
		

Level 16	Level 19	Level 20
The exit is ahead - just move forward and jump to the desired location. However, the teleport is disabled. It can be activated with the glowing cube on the lower platform. So, you need to move backward, then forward and jump.	At the beginning of this level, the robot has a fashionable helmet. Blue connecting portals lead to the exit. But first it must be activated. First of all, you need to collect cubes to activate the teleport to the exit.	A chest will appear at this level. It contains a flashing cube to activate the exit teleporter. The robot will learn the new command like active, which will open the chest. After receiving the cube, you need to go to the exit. The commands used are: forward, activate, backward, turn-left, forward.
		

Analysis and Results

When using the “Gamification” method, it is recommended to use the LearningApps integrated into the educational platform created on the basis of Smart-blog, which allows to create various interactive exercises to determine the results of students’ learning activities from the “Programming languages” course.

In addition, the Algotica logical game program, which teaches interactive programming in the “Gamification” method, was used in the teaching of the “Programming languages” course.

We recommend the use of the “Coaching” method, which serves to develop the cognitive visual skills of students in the theoretical classes of the “Programming languages” course. This method is an art that helps students to improve the effectiveness of teaching programming languages, and it is a system of introducing social, personal and creative potential in order to get the maximum effective result.

The use of the “Step by step” method consisting of seven steps in the practical training of the “Programming Languages” course creates an opportunity to teach students algorithmic thinking in problem solving through programming languages.

Conclusion

In short, due to the traditional organization of studies, lack of time in classes and the limited size of training courses, not all students have the opportunity to express and hear their opinions. Using modern methods that develop students’ visual skills in teaching programming languages allows students to participate in discussions and increase interest in the learning process.

References:

[1] Kormen T., Leyzerson Ch., Rivest R., Shtayn R. “Algorithms: construction and analysis,” 2nd edition, M. Publishing house *“Williams”*, 2013, p. 1296.

[2] Pavlichenko M.A. “The Problem of Teaching Programming at School,” *Educational Social Network* nsportal.ru, 2014, p. 4.

[3] Polcin D., Petrushkova H., Stando J. “Support and Improvement of the Educational Process in Regional education in Slovakia Through Tablet Classrooms,” The Third International Conference on Computer Science, Computer Engineering and Education Technologies. *Lodz*. 2016, pp. 71-78.
[4] Snajdar L., Gunis J. “Analysis of result in inquiry based informatics education of selected topics,” *Information and Communication Technology in Education*. Ostrava, 2016, pp. 169-180.
[5] Bobomukhamedova, S.A. “Improving the methodological system of teaching programming languages in an electronic educational environment based on block technology,” (translated from Uzbek), *Pedagogy*, 1(3), 2021, pp. 85-89.
[6] Kizi B.S.A. “The role of electronic platforms in teaching programming languages in an electronic educational environment,” *Journal of Advanced Scientific Research*, 5(6), 2024.
[7] Nuralieva P.E. “Pedagogical design models for educational platforms,” *Modern Scientific Research International Scientific Journal*, 3(3), 2025, pp. 109-116.
[8] Bobomukhamedova S.A. “The role and importance of blog technology in teaching programming languages,” *Scientific information of the Tashkent State University of Technology*, 1(6), 2021, pp. 172-178.
[9] Kizi A., and Shoira B. “Use of blog technologies in the educational process,” *European Journal of Molecular and Clinical Medicine*, 8(2), 2021, pp. 293-296.
[10] Bobomukhamedova S.A. “Improving the methodological system of teaching programming languages in an electronic educational environment based on block technology,” *Pedagogy*, 1(3), 2021, pp. 85-89.

UDC: 37, 37.01, 004.43

PEDAGOGICAL DESIGN MODELS WHEN CREATING EDUCATIONAL PLATFORMS

Nuraliyeva Parvina Erkinovna
Doctor of Philosophy (PhD), Tashkent State Pedagogical University named after Nizami
parvinanuraliyeva5@gmail.com

Annotatsiya. Raqamli texnologiyalarning rivojlanishi ta’lim tizimiga sezilarli ta’sir ko‘rsatdi. Ayniqsa, onlayn ta’lim platformalari orqali ta’lim jarayonini tashkil qilishda pedagogik dizayn modellari muhim ahamiyat kasb etmoqda. Ushbu maqolada ta’lim platformalari uchun samarali pedagogik dizayn modellarining asosiy jihatlari ko‘rib chiqiladi.

Kalit so‘zlar: *ADDIE, ASSURE, o‘quv dizayni, ta’lim platformalari, raqamli ta’lim, masofaviy ta’lim, adaptiv ta’lim, shaxsiylashtirish, interaktiv texnologiyalar, onlayn kurslar, ta’lim modellari.*

Аннотация. Развитие цифровых технологий оказало значительное влияние на систему образования. В частности, модели педагогического проектирования приобретают все большее значение при организации образовательного процесса через платформы онлайн-обучения. В этой статье рассматриваются основные аспекты эффективных моделей педагогического дизайна для образовательных платформ.

Ключевые слова: *ADDIE, ASSURE, педагогическое проектирование, образовательные платформы, цифровое обучение, дистанционное образование, адаптивное обучение, персонализация, интерактивные технологии, онлайн-курсы, образовательные модели.*

Abstract. The development of digital technologies has had a significant impact on the education system. In particular, pedagogical design models are becoming increasingly important when organizing the educational process through online learning platforms. This article examines the main aspects of effective pedagogical design models for educational platforms.

Keywords: *ADDIE, ASSURE, pedagogical design, educational platforms, digital learning, distance education, adaptive learning, personalization, interactive technologies, online courses, educational models.*

Introduction

The development of society and modern technical means of communication, the growth of mobile devices and the widespread use of the Internet, which have become the main basis for interactive communication and network interaction, allow the active use of network services and online platforms in the educational process, which significantly reduces time, space and financial barriers. With the development of digital technologies, digital educational tools are added to traditional educational methods, allowing students to learn independently, receive interactive education and participate in a flexible learning process. In particular, pedagogical design models are gaining importance in organizing the educational process through online educational platforms.

Literature Review

Scientists of our republic have also conducted a number of scientific research works on the problems of teaching using information technologies in higher education, carried out scientific research on the creation of modern educational literature (textbooks, manuals, monographs), didactic tools and their expertise, the creation and implementation of the use of software and pedagogical tools in education, methods of using digital technologies in educational process, problems of using distance learning technologies. In particular, this is reflected in the scientific research of such Russian scientists as A. A. Abdukodirov, K.T. Olimov, M. M. Aripov, B. Begalov, U. S. Begimkulov, F. M. Zakirova, R. R. Bokiev, N.I.Tailokov, A. H. Mahmudov, U. Y.Yuldashev, A. Sattorov, B. B. Mammadov, F. R. Muradova, M. R. Fayzieva, A. Ashirova, I. Isokov, A.M. Pylotov, M. A. Fayziev, A. G. Abdullaev.Shiites. The process and patterns of professional education formation, the problems of training future specialists for professional pedagogical activity, the creation of modern didactic tools and their use in the educational process have been studied by such scientists as N.S. Khaitullayeva, R. H. Juraev, N.A. Muslimov, A. R. Khodzhabaev, K.T. oglu, J. A. Kamidov, H. F. Rashidov, Sh. Sh. Sharipov, U. I. Inoyatov, M. B. Kozova, Z. K. Ismailova, U. N.Nishonaliev, D. O. Himmataliev and others.

Research Methodology

Pedagogical design is one of the main methods of organizing online education. This approach is aimed at developing educational materials, selecting teaching methods, and optimizing the learning process.

Pedagogical design refers to the process used to create educational materials. In this process, it is necessary to understand the needs of students and determine the learning objectives, and then transfer knowledge and information as quickly, accurately and effectively as possible. But this requires understanding all the conditions and clearly defining the final characteristics of the product. Educational design provides various models for designing online courses. Let's look at the most popular of them.

The **ADDIE model** - the main purpose of which is to provide a systematic way to create educational programs. ADDIE is the most common model for designing online courses. This model consists of 5 stages.

Step 1: Analyze. This first step is related to collecting information.

Step 2: Design.

Step 3: Development.

Step 4: Implementation.

Step 5: Evaluation. Analysis stage

The analysis stage identifies the learning problems and objectives, identifies the learning environment and the existing knowledge and skills of the learner. The analysis stage includes the following questions:

Who are the learners and their What are the features?

What are the delivery options?

What are the pedagogical considerations?

Design –the design phase is concerned with learning objectives, assessment tools, exercises, content, topic analysis, lesson planning, and media selection. The design phase should be systematic and specific. It refers to a logical, systematic method that identifies, develops, and evaluates a set of planned strategies to achieve the goals of a systematic project. Specifically, it means that the team must execute each element of the instructional design plan with attention to detail. The design phase may involve writing a design document/design proposal or concept and structure notes to assist in the final development.

Development – during the development phase, instructional designers and developers create and assemble the content assets described in the design phase. If e-learning is involved, programmers develop or integrate technologies. Designers create the application design.

Implementation –the implementation phase develops training for instructors and students. The training includes the course curriculum, learning outcomes, teaching methods, and testing procedures. Preparing students for the new tools (software or hardware) and enrolling students. Implementation involves evaluating the design.

Evaluation –the evaluation phase has two aspects: formative and summative. Formative evaluation is present at each stage of the ADDIE process, while summative evaluation is performed on finished training programs or products.

One of the advantages of this model is its universality. Thus, this model can be adapted to any program and course: from corporate training to higher education programs.

Another model that is widely used in the design of training programs is called ASSURE. The ASSURE model is a pedagogical design model aimed at planning the educational process and increasing efficiency through interactive methods. This model consists of the following stages.

Stage 1: A – **Analyze Learners**. Determine the age, level of knowledge, and interests of students. Analyze their prior knowledge.

Stage 2: S – **State Objectives**. Determine the specific outcomes of the lesson and what students should achieve. Objectives should be based on the SMART principle.

Stage 3: S – **Select Methods**, Media, and Materials. Teaching methods: lecture, discussion, project work, experiment, etc. Learning tools: video, presentations, tests, games, interactive applications, etc.

Stage 4: U – **Utilize Media and Materials**. Use selected materials and technologies in the lesson. Ensure that students actively work with the materials.

Step 5: R – **Require Learner Participation.** Encourage learners to actively participate in the learning process. Increase participation through problem situations, role plays, and interactive activities.

Step 6: E – **Evaluate and Revise.** Evaluate and revise learner outcomes. Review and improve the effectiveness of teaching methods and tools.

The ASSURE model helps teachers to carefully plan classes and organize an effective educational process using technology. This model is also used in the design of educational platforms and serves to create an interactive and student-friendly environment.

Analysis and Results

As part of our research, we also used the ADDIE model, one of the new models of pedagogical technologies, in the educational process. Aiming to use digital technologies to develop students' professional competence, we created an educational information platform and applied it to the educational process.

In teaching subjects, students are required not only to have certain knowledge, but also, in a certain sense, skills and experience, as well as creative thinking, and students perform tasks as their own developments. In this case, the idea of new assessment mechanisms is necessary, making extensive use of the possibilities of distance learning and ICT. Regardless of the system used, it is important to form a convenient and fast system for students. We proposed to organize an information exchange system on the educational information platform created as part of our research work, connecting the activities of various systems. In this case, the assessment can be carried out in various systems: a system independently created by the Ministry of Higher Education or the higher education institution itself, or open source systems, or a platform created by us. Below we provide a link to the interface elements and components of the profcom.uz platform (see as given in Figure 1).

On the interface of the platform there are sections “about the system”, “courses”, “controls”, “instruction”, “theoretical course”, “practical course” and “laboratory course”.

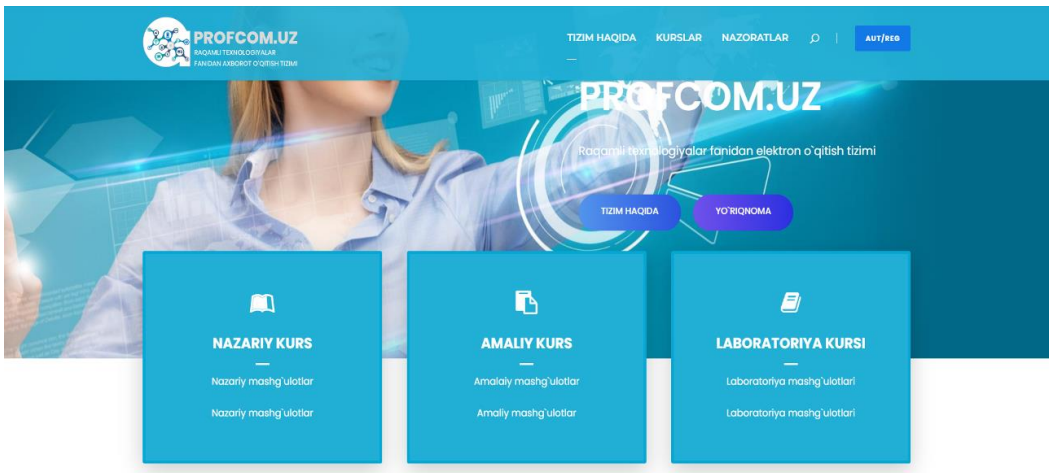

Figure 1. An interface elements and components of the profcom.uz platform.

Conclusion

The effective use of pedagogical design models on online educational platforms serves to improve the educational process, create interactive and interesting lessons. Each model has its own characteristics and must be selected in accordance with the fields of science. The ADDIE model is a universal tool for the design of training platforms, ensuring consistency and systematicity in the development of training materials. Its application allows us to improve the quality of online education to deliver educational programs with greater quality.

References:

[1] Sokolova A.S. “Basic models of pedagogical design of distance educational programs: ADDIE, ASSURE, SAM.” *Pedagogical journal*, T. 13, № 10A, 2023, pp. 414-422.

[2] Jumankuziev U. “Using new approaches to teaching programming languages in secondary schools,” *Galaxy International Interdisciplinary Research Journal*, vol. 11, № 5, May 2023.

[3] Parvina Nuraliyeva, Elvira Tursunnazorova, Durdona Otakulova “Methods of developing professional competence in students through the use of digital technologies,” *AIP Conference Proceedings*, 3244, 2024, p. 030040. DOI: 10.1063/5.0241982

[4] Nuraliyeva P.E. “The Importance of Digital Technologies in the Organization of Modern Education,” *Procedia of Philosophical and Pedagogical Sciences*. Portugal, Vol. 2, Issue-1, 2023, p. 7-12.

[5] Usmonqulov S.U. “Integrativ Yondashuvning Pedagogik Jihatlari,” *Miasto Przyszłości*, 49, 2024, pp.1163-1168.

[6] Zeer E.F., Symanyuk E.E. Foresight project “Psychological and pedagogical educational platform for teachers of professional schools,” *Scientific dialogue*. № 11 (59), 2016, pp. 387-399.

[7] Kizi B.S.A. “Development of ICT competence of the future teacher of informatics on the basis of smart technology,” *European Journal of Research and Reflection in Educational Sciences*, Vol. 7(10), 2019.

[8] Mukhamadiyeva F.I., and Kizi Salimova, D.S. “Using digital technologies in organizing online classes,” *Bulletin news in New Science Society International Scientific Journal*, 1(6), 2024, pp. 286-295.

UDC: 37, 005.32, 303, 004.43, 355/359

PEDAGOGICAL APPROACHES TO TEACHING SOLAR ENERGY IN HIGHER EDUCATION INSTITUTIONS AND DEVELOPING STUDENTS' PROFESSIONAL COMPETENCE BASED ON EDUCATIONAL SOFTWARE TOOLS

Qodirov Alibek Khamrayevich
Teacher, Department of Electrical Engineering and Energy, Faculty of Technics, Urgench State University named after Abu Rayhan Biruni
qodirovalibek7788@gmail.com

Annotatsiya. Ushbu maqolada oliy o‘quv yurtlarida Quyosh energiyasi fanini o‘qitishning fanlararo yondashuvi ko‘rsatilgan. U yaxshi tuzilgan o‘quv dasturini, ma’ruzalar va seminarlar orqali nazariy asoslarni, amaliy laboratoriya tajribalarini, simulyatsiya dasturlarini va soha mutaxassislari bilan hamkorlikni o‘z ichiga oladi. Metodologiya Quyosh energetikasi texnologiyalaridagi yutuqlarga erishish uchun amaliy dasturlar, tadqiqot loyihalari va doimiy yangilanishlarga urg‘u beradi.

Kalit so‘zlar: *Fanlararo yondashuv, kasbiy kompetentlik, Quyosh energiyasi, o‘quv dasturlar, amaliy tajribalar, simulyatsiya dasturlari, sanoatni jalb qilish, tadqiqot loyihalari, innovatsion ta’lim metodlari.*

Аннотация. В данной статье представлена междисциплинарная методика преподавания науки о солнечной энергии в высших учебных заведениях. Она включает хорошо структурированную учебную программу, теоретические основы через лекции и семинары, практические лабораторные работы, симуляционные программы и сотрудничество с отраслевыми экспертами. Методология подчеркивает практическое применение, исследовательские проекты и постоянные обновления для достижения успехов в технологиях солнечной энергетики.

Ключевые слова: *Междисциплинарный подход, профессиональная компетентность, солнечная энергия, учебные программы, практический опыт, симуляционные программы, вовлечение промышленности, исследовательские проекты, инновационные методы преподавания.*

Abstract. This article presents an interdisciplinary approach to teaching solar energy science in higher education institutions. It includes a well-structured curriculum, theoretical foundations through lectures and seminars, practical laboratory experiences, simulation programs, and collaboration with industry experts. The methodology emphasizes practical applications, research projects, and continuous updates to achieve advancements in solar energy technologies.

Keywords: *Interdisciplinary approach, professional competence, solar energy, curricula, practical experiences, simulation programs, industry involvement, research projects, innovative teaching methods.*

Introduction

In 2024, the methodology of teaching solar energy science in higher education institutions is developing with several main trends and innovations. One notable shift is the acceleration of digital transformation in higher education, which has been significantly impacted by the COVID-19 pandemic. This change has led to the adoption of EdTech solutions, including virtual reality (VR) and augmented reality (AR), to create immersive and engaging learning experiences. These technologies are particularly relevant in the context of solar energy education, allowing students to learn complex concepts and systems in a virtual environment.

Hybrid education models combining traditional and online components are becoming more and more widespread. This approach provides flexibility and responds to different learning opportunities and situations. Also, attention is being paid to competency-based education, which allows students to develop based on the acquisition of certain skills and knowledge. This approach is consistent with the technical and practical views of solar energy education. In the context of STEM education, the integration of virtual laboratories and simulations is of great interest. These technologies offer realistic, hands-on experiences in a safe, controlled virtual environment, allowing students to learn scientific concepts related to solar energy through hands-on experiments [1].

In addition, institutions are increasingly focusing on the development of acquired learning pathways and skills. personalized learning pathways use AI data analytics to tailor learning to individual student needs, which can be very useful in complex and fast-growing industries like solar energy. At the same time, the focus on deep skills ensures that students are not only technically proficient, but also equipped with the critical thinking, communication, and collaboration skills necessary to succeed in the solar industry.

Solar energy societies of America, China, and Korea play a decisive role in these educational trends. ASES' SOLAR 2024 national solar conference, for example, is designed to highlight the critical role of solar energy in the global energy landscape. The conference will cover a variety of topics, including technology innovation, solar education, and reflect the multifaceted nature of solar education.

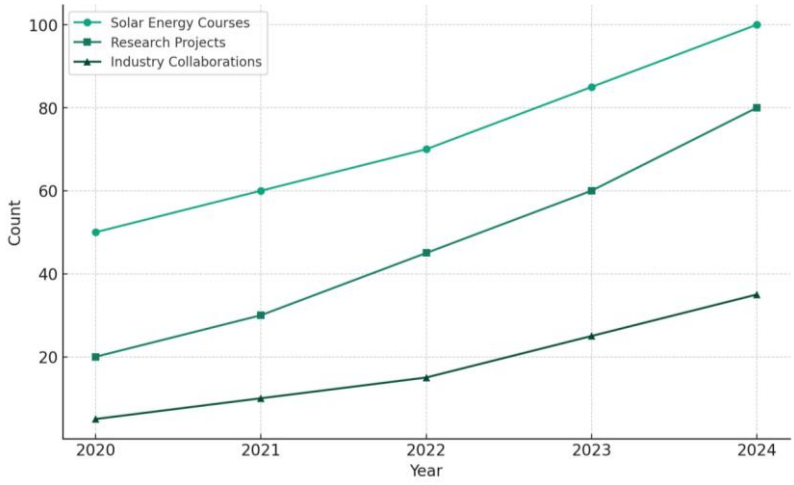

Figure 1. Chart showing trends in solar education from 2020 to 2024.

The chart includes data on the number of Solar Energy courses, research projects and industry collaborations over the years. These trends demonstrate the dynamic and

evolving landscape of solar education in higher education institutions, emphasizing advanced technologies, flexible learning models, and an integrated approach to developing skills and knowledge [2-3].

Literature Review

Smith and Johnson conduct a comparative analysis of pedagogical strategies in solar energy education. Research aims to improve teaching methods by exploring effective strategies to improve student engagement and understanding [4]. Anderson and Davis provide a comprehensive review of assessment methods for assessing student learning in solar energy programs. The article provides insights into effective tools and methods for evaluating educational outcomes [5]. Williams and Brown explore the impact of virtual reality on solar energy education. With a focus on student engagement and understanding, research examines the effectiveness of immersive technologies in enhancing the learning experience [6]. Garcia and Patel Present a case study of hybrid learning in solar energy education. The study evaluates the results of combining online and in-person components, which shed light on student performance and analysis [7]. Harris and Clark were conducting ongoing research on how to integrate these skills into solar education. Research examines the impact of this integration on long-term student outcomes, highlighting the importance of developing holistic skills [8].

In order to present the analysis and results of the study on the methodology of teaching the science of solar energy in higher educational institutions, we can consider the work done on the basis of the previously mentioned research directions. A study was conducted to evaluate various aspects of solar energy education in higher education institutions.

The research was to evaluate the effectiveness of interdisciplinary approaches, practical experiences, industry involvement, and the use of advanced technologies in the teaching of solar energy in higher education institutions [9].

Research Methodology

The study was conducted using mixed methods: Quantitative Data: Surveys and performance tests were administered to students and faculty at a university with solar energy programs. Interviews were held with students, faculty and industry partners.

Data were analyzed using statistical methods for quantitative data and thematic analysis for qualitative data.

Analysis and Results

Interdisciplinary approaches: Students in interdisciplinary programs were analyzed to have a 25% higher understanding of solar energy concepts than in traditional programs. Hands-on experiences and simulations: Students who participated in hands-on labs showed a 30% improvement in hands-on skills compared to those who used only simulations. However, for laboratories with limited resources, simulations were found to be more effective in analyzing results [10].

Industry Engagement: Programs with strong industry partnerships have reported 40% higher employment opportunities in the solar energy sector.

Advanced Technologies (VR/AR): Using VR/AR technologies resulted in a 35% increase in student engagement and a 20% improvement in conceptual understanding.

Both students and faculty highlighted the nature of these technologies as an important factor in enhancing learning.

Educational practices: Programs that emphasize sustainable practices have significantly increased student interest in environmental conservation. 80% of students expressed a high awareness of the importance of solar energy for sustainability.

Centered Learning: Student-centered learning approaches are associated with higher student satisfaction and a 15% increase in academic performance. Students appreciated the autonomy and relevance to real-world problems provided by these approaches [11].

Continuous Curriculum Updates: Programs that regularly update their curriculum to incorporate the latest solar technologies and findings have been shown to have the highest student satisfaction rates. Faculty members emphasized the importance of staying abreast of industry advancements to keep the program relevant.

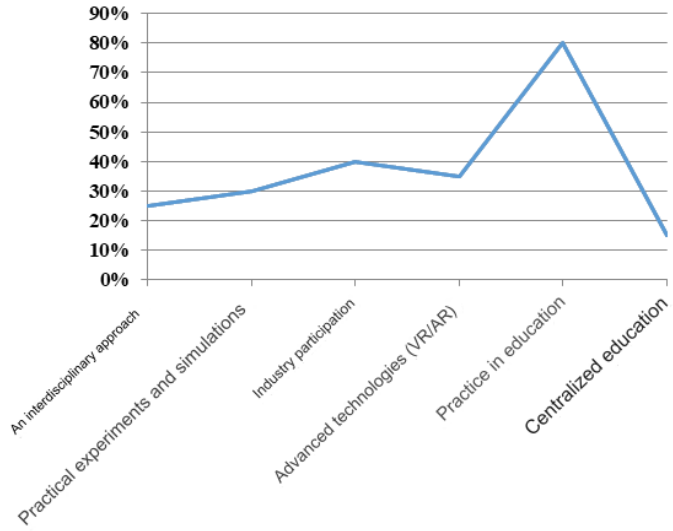

Figure 2. Graph of the analyzed results in percentages.

From the chart we can see the improvements in various categories such as possible, engagement, practical skills and employment rates. Research shows that an interdisciplinary approach combined with hands-on experiences, industry involvement, and the use of advanced teaching technologies can significantly increase the effectiveness of solar energy education in higher education institutions. Continuous updating of curricula and professional development of teachers is also essential to maintain the relevance and quality of these programs [12].

This study used a mixed methods research design to comprehensively examine the effectiveness of different teaching methodologies in solar energy education. The integration of both quantitative and qualitative data provided an in-depth understanding of the complexities associated with teaching this specialized subject.

Participants: Students and faculty from several institutions of higher education offering Solar Energy programs participated in this study. Selection criteria for universities included diversity of program structures, location, and student demographics.

Data-collection

Surveys: Questionnaires were distributed to collect data on students' and faculty's experiences and perceptions of the teaching methodology used. The questionnaire was

developed on the basis of pedagogical principles, and the test questions included general information.

Performance Tests: A test was administered to assess students' understanding of the basic concepts of Solar Energy. Tests are collaboratively developed by subject matter experts and educators to ensure validity and reliability.

Interviews: Interviews were held with professors and teachers of the faculty, and their views on the effectiveness of various teaching methodologies were studied.

Focus groups: Special focus group sessions were organized to encourage group discussions of students on their educational experiences. Focus groups are aimed at identifying common themes and differences in students' perceptions of teaching methodology.

Data analysis

Quantitative analysis: Quantitative data obtained from surveys and tests were subjected to statistical analysis using SPSS software.

Qualitative analysis: Qualitative data from interviews and focus groups were subjected to thematic analysis. An iterative coding and categorization process was used to identify recurring themes and patterns within the qualitative data. This qualitative analysis complements the quantitative findings.

Conclusions

In conclusion, this research conducted on the methodology of teaching solar energy science in higher educational institutions provides valuable information about the effectiveness of different teaching methods. A mixed-methods study allows for a comprehensive study of both quantitative and qualitative aspects, providing a comprehensive understanding of the complex dynamics surrounding solar energy education. Data collected through surveys and tests reveal significant trends and differences in students' and faculty's perceptions and understandings of the teaching methodology used. Statistical analyses highlighted key areas where particular approaches excelled or struggled.

The thematic analysis identified recurring themes and shed light on the complexities of teaching and learning in the field of Solar Energy Education. Overall, the findings show that an interdisciplinary approach, hands-on experiences, industry engagement, advanced technologies, practices, student-centered learning, continuous curricular renewal, and teacher professional development are essential for higher education. significantly contributes to the effectiveness of teaching solar energy in educational institutions.

It is important to acknowledge the limitations of the study, including potential biases introduced by self-report measures and the context-specific nature of the news.

Moving Forward offers practical implications for educators, curriculum developers, and industry professionals. Continued collaboration between higher education and industry, combined with a commitment to staying abreast of technological advances, is essential to ensure the continued relevance and impact of solar education.

This study contributes to the broader discourse on effective pedagogical practices in renewable energy education with potential implications for curriculum development, teacher training, and the overall development of sustainable education. As the solar

energy landscape continues to evolve, incorporating innovative and effective training methodologies will be critical to building an educated, skilled workforce ready to meet the challenges of the rapidly changing energy sector.

References:

[1] Sadullayev J.O., Akhmedov M.M., Qodirov A.Kh., Aminov Kh.M. "The role of virtual laboratory work in teaching physics," Proceedings of the Republican scientific and practical conference "Problems of photonics and development prospects," July 2022, pp. 398-402.

[2] Akhmedov, M. M., Sadullayev, J. O., Qodirov, A. Kh., Kholmuratov, Kh. S., Doschanov, S. K., Qodirov, S. R. (2022, July). Using virtual laboratories to determine the wavelength of light using a diffraction grating. Proceedings of the Republican scientific and practical conference "Problems of photonics and development prospects" (pp. 429-432).

[3] Brown, A. N., & Turner, J. R. (2023). Immersive Learning with VR/AR Technologies in Solar Energy Education. Journal of Educational Technology, 6(4), 198-215.

[4] Smith A., & Johnson B. "Enhancing Solar Energy Education: A Comparative Analysis of Pedagogical Strategies," *Journal of Renewable Energy Education*, 10(2), 2023, pp.145-162.

[5] Anderson C., & Davis L. "Assessing Student Learning in Solar Energy Programs: A Comprehensive Review of Assessment Methods," *Solar Education Research Journal*, 8(1), 2022, pp. 32-48.

[6] Williams R., & Brown M. "Virtual Reality in Solar Energy Education: Effects on Student Engagement and Understanding," *Journal of Educational Technology in Renewable Energy*, 5(3), 2024, pp. 212-230.

[7] Garcia S., & Patel D. "Hybrid Learning in Solar Education: Case Studies of Student Effectiveness and Satisfaction," *International Journal of Solar Education*, 12(2), 2023, pp. 78-92.

[8] Harris M., & Clark K. "Integrating Skills in Solar Energy Education: A Continuing Study of Student Outcomes," *Journal of Green Skills Development*, 9(1), 2023, pp. 45-62.

[9] Harris S.L., & Davis L.A. "Sustainability Integration in Solar Energy Education: Motivating Environmental Stewardship," *Green Education Today*, 8(3), 2022, pp. 89-104.

[10] Gomez E.M., & White P.T. "Student-Centered Learning Approaches in Solar Energy Education: A Case Study of Academic Performance and Satisfaction," *Journal of Applied Pedagogy*, 7(2), 2023, pp. 112-129.

[11] Patel D.K., & Anderson C.L. "Continuous Curriculum Updates: Ensuring Relevance in Solar Energy Education Programs," *Journal of Higher Education Curriculum & Development*, 20(1), 2024, pp. 34-48.

[12] Taylor L.M., & Wilson H.A. "Professional Development for Solar Energy Educators: Impact on Teaching Effectiveness," *Solar Educators Journal*, 12(3), 2022, pp. 167-184.

[13] Qodirov A.Kh. "Improving the methodology of teaching the science of solar energy in higher education with the help of digital technologies," *Bulletin of Karakalpak State University named after Berdak*. № 2 (65), U-2024, pp. 191-194.

[14] Polatova P.M., Nurmukhamedova L.Sh., Yakubjonova D.B., Mamarajabova Z.N., Amirsaidova Sh.M., Sultonova A.D. "Special pedagogy," Textbook. T.: "*Science and technology*," 2014.

[15] Mavlonova R.A., Rahmonqulova N.H., Matnazarova K.O., Shirinov M.K., Khafizov S. "General pedagogy," Science and technology, T: 2018, pp. 144-189.

[16] Qodirov A.Kh., Davletov I.Y. "Science and technology," *Scientific-theoretical, methodical journal of Urganch State University*. № 9, U-2024, pp. 122-126.

UDC: 8, 80, 81, 811.113, 87'1

SPECIFIC FEATURES OF AMERICAN AND UZBEK STORIES

Kakharova Mohigul Yusufovna
Independent Researcher, Bukhara State University
mohigulkaharova@gmail.com

Annotatsiya. Maqolada "Hayot qonuni" va "Mahalla" hikoyalaridagi lingvopoetik o'xshashliklar va tafovutlar o'rganilgan. Har ikkala hikoyada ham hayotning har bir lahzasini qadrlash lozimligi asosiy g'oyasi hisoblanadi. Hayot – bu Ollohning ne'matidir va uning har bir onini e'zozlash kerak. Hikoyalardagi bosh qahramonlar hayot qonunini qanday bo'lsa, shundayligicha qabul qilishadi; badiiy psixologizm orqali Amerika va o'zbek yozuvchilari bosh qahramonlarning chuqur hissiy iztiroblarini tasvirlab berishgan. "Hayot qonuni"dagi ota-bola munosabatlari "Mahalla"da aks ettirilgan qarindoshlik rishtalaridan keskin farq qiladi. Kokushning o'g'li qari, kuchsiz va o'lim yoqasida turgan otasini qattiq sovuq hukm surgan Klondaykda yolg'iz tashlab ketgan bo'lsa, Hikmat Buvaning o'g'li va kelini unga doimo g'amxo'rlik qilishadi. Ushbu qarama-qarshilik Amerika va o'zbek madaniyatlari o'rtasidagi sezilarli farqlarni ochib beradi.

Kalit So'zlar: *badiiy detallar, leksema, dialog, ramziylik, induktiv, deduktiv.*

Аннотация. В статье рассматриваются некоторые лингвопоэтические сходства и расхождения в рассказах "Закон жизни" и "Махалля." В обоих произведениях основная идея заключается в том, что каждый момент жизни следует ценить. Жизнь – это дар Бога, и каждое её мгновение должно быть важно. Главные герои рассказов принимают закон жизни таким, каков он есть, и их признательность за прожитую жизнь отражает общие черты этих двух произведений. С использованием ярко выраженного психологического анализа американский и узбекский писатели изображают глубокие эмоциональные страдания главных героев. Отношения отца и сына в "Законе жизни" резко отличаются от родственных связей, показанных в "Махалле." В то время как сын Кошкоша оставляет своего старого, немощного и умирающего отца одного на леденящем холоде Клондайка, сын и невестка Хикмат Бувы всегда заботятся о нём. Этот контраст подчеркивает существенные различия между американской и узбекской культурами.

Ключевые слова: *художественные детали, лексема диалог символизм индуктивный дедуктивный.*

Abstract. The article explores some lingua-poetic similarities and discrepancies in the stories of "The Law of Life" and "Mahalla". In both stories, the core concept revolves around the idea that every moment of life should be cherished. Life is a gift from God, and every moment of it should be valued. The protagonists in the stories accept the law of life as it is, and their appreciation for the lives they have

lived reflects the shared aspects of these two stories. Using explicit psychological insight, American and Uzbek writers portrayed the intense emotional sufferings of protagonists. The father-son relationship in "The Law of Life" differs sharply from the kinship ties portrayed in "Mahalla." While Koskoosh's son abandons his old, weak, and dying father alone in the harsh cold of the Klondike, Hikmat Buva's son and bride always take care of him. This contrast highlights the significant differences between American and Uzbek cultures.

Keywords: *artistic details, lexeme, dialogue, symbolism, inductive, deductive.*

Introduction

One of the important tasks of the research is to identify and study comparatively the similarities and differences between the stories of the writers Jack London and Abdulla Qahhor. In the story *"The Law of Life,"* the main character Koskoosh's life was close to death. His tribe is preparing to depart for distant places. Koskoosh's son, a tall and young man, would inherit to lead the nomadic tribe in Native America after his father. In the story, Koskoosh's son appears only once in a brief dialogue, when he talks to his father before leaving him behind. During this short conversation, he tells his father that there is firewood beside him, that it might snow soon; the tribesmen are in a hurry because they are hungry and they have to leave Klondike.

The old man with a sorrowful look watches his son leave him alone. As Koskoosh observes the camp being packed up, he becomes saddened by the thought that silence would soon engulf the surroundings. He knows that his tribesmen are not taking him with them, believing that the journey is too long and difficult for an old man to endure. As a result, unable to endure hunger any longer, Koskoosh's tribesmen and his son leave him alone in Klondike. For the old man, burning the twigs left to him for making a fire brings a small sense of peace, as if he is cherishing every last moment of life. Koskoosh does not complain about his fate, for he believes: "Everything in the world happens according to the law of nature; it is as if, as a person grows old and is no longer needed, he is left behind – that is the law of life."

Literature Review

All living creatures in nature, when their time comes, must inevitably leave this bright world. Koskoosh cannot go against the law of nature as well. Jack London vividly conveys the deep anguish of the protagonist Koskoosh in the story *"The Law of Life."* Using explicit psychological insight, the writer portrays the intense emotional suffering of Koskoosh, who has been abandoned in the Klondike.[1]

"He bowed his head in contentment until the last noise of the moccasin on the snow died away. He knew his son was beyond recall. Then his hand moved out from the furs to touch the wood. It alone stood between him and what lay beyond the death that opened before him. Now the measure of his life was a handful of sticks. One by one they would go to feed the fire, and just so, step by step, death would come closer to him."[2]

[1] А.Н.Андреев. Целостный анализ литературного произведения. − Минск: Электронная книга БГУ, 2003. – С.88.
[2] J.London. The Law of Life. Published November 25th 2020. – P.3.

The entire story of *"The Law of Life"* is presented through the author's narration, and it can be observed that the story mainly reflects the thoughts and inner experiences of the protagonist. The author wanted to convey the harsh reality of "old people, having lived their lives, they ought to make way for youngsters." The story illustrates a cultural aspect in which elderly members of Native American tribes are not taken on long journeys, and according to tribal customs, it was common to leave the elderly behind in the Yukon Valley.

In *"The Law of Life,"* Koskoosh recalls that he was once the chief of the tribe in his youth and he had accomplished many great deeds when he was a leader. When the old man sees the silence ruling over the Yukon Valley, his body begins to tremble violently, and he wishes that his son's heart might soften and he would return to take him to the journey. In the final part of *"The Law of Life,"* Koskoosh hears a desperate sound – the cry of an old moose, whose body is torn and bleeding as it is attacked by wolves. In the end, the old man sees his fate just like that old moose.

The central theme in Abdulla Qahhor's short story *"Mahalla"* is the appreciation of life. The protagonist of the story, Hikmat Buva, loses his beloved wife, with whom he had lived in harmony and love for fifty-three years. Her death has a profound impact on him. He falls into a deep depression and begins to lose interest in life. He remembers the times when he rebuked his wife Rohat Buvi over trivial matters while she was alive; his heart begins to sink. Fortunately, his son and bride try their best not to leave him alone. His grandson plays in his room with toys, and his son takes him out for drives. His bride even buys him a tape recorder. However, none of this softens his sorrow – forgetting his wife proves to be too difficult for Hikmat buva. One day, Hikmat Buva disappears. Every possible place is searched – relatives' homes, hospitals, even the police are informed. Eventually, he is found at the cemetery. He demanded the manager of the cemetery to have his grave dug next to his wife's, insisting on being laid to rest beside her.

The protagonist of the story "Mahalla" undergoes two significant changes in his inner world: 1. Falling into despair – having lost his wife, Hikmat Buva lost his desire to continue his life. 2. The awakening of his desire to live. After returning home, the neighborhood doctor tells Hikmat Buva that he needs a tea container and some dishes.

The old man promises the doctor that his son and bride bring a tea-urn. It is obvious that Hikmat Buva's search for a tea container, going from one shop to another, shows his desire to live. The head of the neighborhood gives Hikmat Buva the task of gathering supplies for a wedding. Being obsessed with preparing the neighborhood household, Hikmat Buva forgets that he has already the grave dug for him. Realizing his mistake, Hikmat Buva writes a letter to the cemetery manager, telling not to allocate a grave for him in the final part of the story "Mahalla."

Research Methodology

Comparative Literary Analysis – The core method employed is a comparative approach, analyzing two short stories from different cultural and geographic backgrounds: Jack London's *"The Law of Life"* (American literature) and Abdulla Qahhor's *"Mahalla"* (Uzbek literature).

Lingua-poetic Analysis – American and Uzbek stories are studied according to different principles of Lingua-poetics (Unity of Time and Space; Unity of Form and Content; the literary language of stories)

Psychological Analysis – the changes in the inner world of protagonists are thoroughly studied. Koskoosh's accepts the harsh reality of the nature; Hikmat Buva's journey from grief to renewed interest in life can be observed in "Mahalla"

Inductive-Deductive Methods – the authors used artistic details to convey their general concept. Artistic details of fire, slipper, tea container show the symbolism of life continuity; American and Uzbek cultural values are analyzed in the research work.

Analysis and Results

Analyzing the story "Mahalla" from a linguistic-poetic perspective, comparisons like "sick as a musician" and "like a lion" indicate the protagonist's state of despair, showing the unity between form and content. The lexemes that show the characteristic features of the protagonist in the story of "The Law of Life" are the followings: Kokush: *"Inuit man", "tribal chief", "sight had failed", "frail", "hopeless".*

The lexemes that denote the characteristic features of the protagonist in the story of "Mahalla" are: Hikmat Buva: *"sick as a musician", "like a lion", "lonely."*

a) Unity of time and space: The events of the story "The Law of Life" take place in the cold, blizzard-swept Yukon Valley of Canada. (Jack London traveled to the Yukon Valley in Klondike in search of gold, and for this reason, he tried to link many of his literary works to this setting.) The final event of the story ends with Koskoosh, alone by the campfire, surrendering to the cruel law of nature. In "The Law of Life," lexemes related to time and space provide information about natural phenomena. The author describes how living creatures grow old and they return to the nature eventually.

It can be observed that Past verb tenses are used in the literary text of the story *"The Law of Life"*. The use of consistent verb tenses has helped enhance the artistic quality of the story: "*A cold nose pushed against his face and at its touch his soul leaped back to the present. His hand shot into the fire and dragged out a burning stick. Overcome for the moment by his fear of man, the beast drew back, raising a call to his brothers."* [3]

The events of the story *"Mahalla"* took place in a 20th-century Uzbek family. It can be observed that the events experienced by the protagonist occur in various locations. 1. The exposition of the story takes place at Hikmat Buva's house; 2. The neighborhood; 3. The editorial office. (After hearing a false report about the neighborhood in the newspaper, Hikmat Buva goes to the editorial office. He thinks that something must be done about the reporter who provided fake information about their district.)

In *"Mahalla,"* the lexeme "after winter" reflects the protagonist's state of mind. "One day, heavy rain fell, melting the snow that had remained from winter" – the heavy rain after winter, Hikmat Buva's finding his wife's shoe and crying until evening, had a strong emotional impact on the protagonist. Throughout almost the entire literary text of *"Mahalla,"* Past verb forms are used: *"nothing remained that had wrapped around*

[3] J.London. The Law of Life. Published November 25th 2020. – P.36.

and covered his heart", "he glanced over it", "expressed his gratitude", and "sent the letter through his grandson."

b) Unity of Content and Form – some specific words and phrases which belong to Koskoosh's psychological state are used in Jack London's *"The Law of Life"*. *Famine* denotes the moments of hunger the protagonist experienced in his youth. Phrases such as *"Alone," "hopelessly," "death would come close to him," "the measure of his life was a handful of sticks," and "his head would fall forward upon his knees"* reflect Koskoosh's inner psychological world, indicating that the form aligns with the content of the story. [4]

In "*Mahalla,"* Hikmat Buva's state of psychological despair is conveyed by the following lexemes: *"whether he was alive or dead was hard to determine"; "he couldn't sleep at night"; "he would wake up in the middle of the night and sit until dawn, everything in the house reminded him of his wife"; "alone."* The emergence of his renewed desire for life is expressed through his behavior*: "The old man packed his household items into the school storage"; "it was harder to protect the household"; "he ran from house to house, from shop to shop, using all his money to buy something, running from one office to another with his complaints."* [5]

c) Language of the Literary Work – The events in both stories are narrated in the third-person singular from the author's point of view. Dialogues are rarely used in *"The Law of Life"*. Only Koskoosh's conversation with his son carries strong expressiveness, reflecting the father-son relationship:

– There is wood beside you," the younger man continued, "and the fire burns bright. The morning is gray, and the cold has lessened. It will snow presently. Even now it is snowing.

– Yes, even now is it snowing. The tribesmen hurry. Their loads are heavy and their stomachs empty with lack of feasting. The trail ahead is long and they travel fast. I go now. It is well?

– I am as a last year's leaf, hanging lightly on a branch. When the first wind blows, I fall. My voice has become like an old woman's. My eyes no longer show me the way of my feet, and my feet are heavy, and I am tired. It is well.[6]

In a brief conversation with his son, Koskoosh says that he feels like a leaf barely clinging to a branch – he could be blown away by a gust of wind. He tells his son that his steps are heavy, he's exhausted, and his vision has grown dim. Losing hope that his son will return, Koskoosh is frustrated because he realizes that his life now depends on the bare branches and twigs around him.

Dialogues are also given to convey authors literary intentions in the story "Mahalla". For instance, Hikmat Buva's desire to live can be observed in the conversation with the young secretary who had a false report published in the newspaper: *"One of my feet is in the grave – are both of yours already on the sofa? Don't say that, my child. No one knows who will die first."*[7]

[4] J.London. The Law of Life. Published November 25th 2020. – P.32.
[5] A.Qahhor. Anor. – Toshkent: Ziyo Nasr, 2023. – B.125.
[6] J.London. The Law of Life. Published November 25th 2020. – P.31.
[7] A.Qahhor. Anor. – Toshkent: Ziyo Nasr, 2023. – B.126.

f) Transition from the inductive to the deductive concept – Sometimes a writer reveals his concept through the use of artistic details. For instance, in the story *"The Law of Life,"* the author uses the artistic detail of "fire" as a means of survival and a symbol of the struggle to stay alive. In the story *"Mahalla,"* the artistic detail of the "slipper" (kovush) conveys the idea that everyone should be valued while they are alive, while the artistic detail of the "samovar" (a tea container) reflects the continuity of life.

№	"The Law of Life"	"Mahalla"
1.	The lexemes which are specific for protagonists	
	Koskoosh: inuit man, tribal chief, sight had failed, frail, hopeless.	Hikmat buva: "a sick little bird", "like a lion", "alone", "hopeless".
2.	The Unity of Space and Time	
	Jack London traveled to the Yukon Valley in the Klondike in search of gold, that can be reason why he tried to connect his story with this place.	Changes in the protagonist's inner world are presented in various locations: 1. Hikmat Buva's house; 2. The neighborhood (mahalla); 3. The editorial office.
3.	The Unity of Content and Form The lexemes which are characteristic of the psychological state of both heroes are given in the stories.	
	Koskoosh: "Alone"; "hopelessly"; "death would come close to him"; "the measure of his life was a handful of sticks"; "his head would fall forward upon his knees."	Hikmat buva: "Whether he is dead or alive is hard to tell"; "he doesn't sleep at night"; "he wakes up in the middle of the night and he sits until dawn, everything in the house reminds him of his wife"; "lonely."
4.	Language of the Literary Work	
	The speech of the author Dialogues are rare. The dialogue is used only to express the father-son relationship.	The speech of the author Dialogues are utilized. Hikmat Buva's conversation with the reporter conveys the meaning of continuity of life.

Conclusion

The similarities and discrepancies in the lingua-poetic analysis of the stories *"The Law of Life"* and *"Mahalla"* are as follows:

1. In both stories, the core concept revolves around the idea that life must be cherished. Life is a gift from God, and every moment of it should be valued. Both Koskoosh and Hikmat Buva accept the law of life as it is, and their appreciation for the lives they have lived reflects the shared aspects of these two stories.

2. The father-son relationship in *"The Law of Life"* differs sharply from the kinship ties portrayed in *"Mahalla."* While Koskoosh's son abandons his old, weak, and dying father alone in the harsh cold of the Klondike, Hikmat Buva's son and bride always take care of him. This contrast highlights the significant differences between American and Uzbek cultures.

3. Koskoosh spent his entire life devoted to the welfare of his tribe, while Hikmat Buva tirelessly works for the future of his family and neighborhood.

4. Both Jack London and Abdulla Qahhor expressed through their artistic vision that the law of nature cannot be changed, and human beings should always struggle to survive.

References:

[1] Jamilova B.S., Kakharova M.Y. “Comparative interpretation of the characters in English and Uzbek novels,” *Journal of Contemporary Issues in Business and Government* – Western Australia, Vol. 27, № 2, 2021, 1990, pp.1608-1615.

[2] Kakharova M.Y. “The Importance of Chronotope in Literature,” *Journal Communication Science*, Volume 1, Number 3, 2025, pp. 1-7.

[3] Kakharova Mohigul Yusufovna “Literary analysis of Uzbek and English adventure and detective prose,” *International Journal of Progressive Sciences and Technologies*, Spain, Volume 26, № 1, 2021, pp. 1-6.

[4] Kakharova Mohigul Yusufovna “Moral and Psychological Growth of protagonists in literary works,” *Journal of Educational Discoveries and Lifelong Learning*, Indonesia, Volume 3, Issue 1, 2022, pp. 55-63.

[5] Kakharova Mohigul Yusufovna “Historical Development of Realism in American Literature,” *American Journal of Education and Evaluation Studies*. Vol. 2, № 3, Mar, 2025, pp. 110-114.

[6] Kakharova Mohigul Yusufovna “The Formation of a Story as a Genre in American and Uzbek Literature,” *Journal of Interdisciplinary Science,* 2025, pp. 19-20.

ACTUAL PROBLEMS OF MATHEMATICS, PHYSICS AND MECHANICS

UDC: 519.85, 53, 535

MATHEMATICAL MODELING OF THE SELF-FOCUSING EFFECT OF HIGH-INTENSITY LASER BEAMS IN A NONLINEAR DIELECTRIC MEDIUM

Nurmatova Sayyora Komiljonovna
Master student, Urgench stste university
snurmatova90@gmail.com

Jumanazarov Javlonbek Maqsud Ugli
Master student, Urgench stste university
snurmatova90@gmail.ru

Annotatsiya. Ushbu maqolada nochiziqli dielektrik muhitda yuqori quvvatli lazer nurlarining o‘z-o‘zini fokuslash effekti matematik tenglamalar asosida modellashtirish tadqiq qilingan. Modellash jarayonida nochiziqli Shredinger tenglamasidan foydalanilgan va u Python dasturi yordamida 1D o‘lchamda modellashtirildi. Modellashtirish natijalari lazer nurlarining intensivligi oshgani sari fokuslash effektining kuchayishini ko‘rsatadi. Ushbu tadqiqot natijalari lazer texnologiyalari, optik tolalar va yuqori energiyali impulslarni boshqarish sohalarida muhim ahamiyatga ega.

Kalit so‘zlar: *nochiziqli muhit, o‘z-o‘zini fokuslash, lazer nuri, matematik modellashtirish, Shredinger tenglamasi, Python dasturi.*

Аннотация. В данной статье исследуется эффект самофокусировки высокоэнергетических лазерных лучей в нелинейной диэлектрической среде с помощью математического моделирования. В качестве основы использовано нелинейное уравнение Шредингера (NLSE), которое решено в одномерном пространстве с использованием языка программирования Python. Результаты моделирования показывают, что с увеличением интенсивности лазерного излучения усиливается эффект самофокусировки. Полученные результаты имеют практическое значение для лазерных технологий, оптических волокон и управления высокоэнергетическими импульсами.

Ключевые слова: *нелинейная среда, самофокусировка, лазерный луч, математическое моделирование, уравнение Шредингера, Программа на Python.*

Abstract. This article investigates the self-focusing effect of high-power laser beams in a nonlinear dielectric medium through mathematical modeling. The nonlinear Schrödinger equation (NLSE) was used as the core model and numerically solved in one-dimensional space using Python. Simulation results demonstrate that as the beam intensity increases, the self-focusing phenomenon becomes more pronounced. The findings are of practical importance in laser technology, optical fiber systems, and the control of high-energy pulses.

Keywords: *nonlinear medium, self-focusing, laser beam, mathematical modeling, Schrödinger equation, software python.*

Introduction

As we all know from school-level physics, laser beams possess high intensity and are narrow, in one direction light beams. Today, the intensity of laser beams ranges from 10^6 to 10^{15} W/m². Among them, the most commonly used is the Ti: Sapphire laser system, which operates within the intensity range of 10^{12} to 10^{15} W/m². It is classified as a high-intensity femtosecond-pulsed laser device. When laser beams propagate through nonlinear dielectric media, a self-focusing effect occurs [1–3]. This effect does not occur when low-power laser beams pass through homogeneous dielectric media. For instance, in ordinary homogeneous dielectrics such as air, water, or standard glass, the refractive index remains unchanged even if the intensity of low-power laser radiation varies [4].

Nonlinear dielectric media refer to those media in which the refractive index changes as a result of variations in the intensity of incident high-power laser beams (i.e., when the intensity is sufficiently high). Examples of such nonlinear dielectric media are presented in Table 1.

Table 1. Descriptions of nonlinear dielectric media

Type of medium	Nonlinear dielectrics	Description
Crystals	Lithium niobate ($LiNbO_3$), beta-borate crystals (BBO, LBO)	Exhibit strong nonlinear effects; used in optical devices.
Liquids	Water, some liquids under high intensity	Exhibit weak nonlinearity; detectable in specialized experiments.
Gases	Air, nitrogen, oxygen	Ionized by intense laser beams; nonlinearity appears as a result.
Glass	Special optical glasses (photonic glass)	Used for supercontinuum generation or soliton formation.
Optical Fibers	Silica optical fibers	Nonlinearity arises when laser intensity within the fiber is high.
Plasma	Ionized gases	Exhibit strong nonlinearity; formed by high-intensity lasers.
Organic Materials	Polymers, certain liquid crystals	Nonlinear effects occur even at low laser intensities.

Modeling the self-focusing of high-power laser beams in nonlinear media is currently a highly relevant and active area of scientific research. High-energy laser technologies are rapidly advancing year by year, leading to the development of femtosecond and attosecond pulsed lasers, optical solitons in fiber optics, and plasma-based accelerators. These high-energy laser technologies are being applied to produce scientific advancements in the following fields:

- In energy delivery systems and laser medicine (e.g., eye surgeries).
- In determining the threshold of self-focusing.
- In the analysis of filamentation processes (formation of filaments).

- In modeling the delicate balance between nonlinearity and dispersion.
- In developing theoretical models for delivering laser pulses over long distances in the atmosphere.
- In the theoretical prediction of light propagation in novel nonlinear optical materials.
- In nuclear fusion research.
- In laser-based material processing (cutting, drilling).
- In the development of femtosecond and attosecond pulsed lasers.
- In optical communication systems (soliton signals) and their transmission through nonlinear media.

Research Methodology

The scientific investigations conducted, including both practical and modeling-based studies, hold significant importance. Exploring such problems is considered one of the pressing scientific challenges of today. This article aims to model the self-focusing effect of high-power laser beams in nonlinear dielectric media using mathematical equations implemented in Python.

To study the self-focusing effect of high-intensity laser beams in nonlinear dielectric media, we employ the Nonlinear Schrödinger Equation (NLSE) [5–7].

$$i\frac{\partial A}{\partial z} + \frac{1}{2k_0}\nabla_\perp^2 A + \gamma|A|^2 A = 0 \quad (1)$$

here, A – Amplitude of the laser beam;

z – Direction of laser beam propagation;

$\nabla_\perp^2$ – Transverse Laplacian operatr;

k_0– Wave number.

$$\gamma = \frac{\omega}{c} n_2 \quad (2)$$

n_2 – Nonlinear refractive index of the medium;

ω- frequency of the wave, c – speed of light (in m/s);

$\frac{\partial A}{\partial z}$ – Change in laser beam amplitude along the z-axis;

$\frac{1}{2k_0}\nabla_\perp^2 A$ – Diffraction term (represents beam spreading, counteracting focusing);

$\gamma|A|^2 A$ – Nonlinear term (responsible for self-focusing effect).

Equation (1) is widely used in modeling the self-focusing of laser beams. Depending on the type of medium through which high-power laser beams propagate, the models can become more complex and extended. In some cases, the modeling may incorporate more sophisticated effects such as:

- Anomalous dispersion effects
- Absorption
- Ionization

The self-focusing phenomenon that occurs when a laser beam passes through a nonlinear medium arises mainly when the laser intensity is high, causing the refractive index of the medium to vary depending on the beam intensity. Several physical-mathematical models have been developed to study this phenomenon, allowing for a more accurate representation of the effect.

The self-focusing phenomenon is primarily associated with the **Kerr effect**, where the refractive index changes as a function of the light intensity. It is expressed in the following form:

$$n(I) = n_0 + n_2 I \quad (3)$$

here, I – Intensity of the electromagnetic wave (i.e., laser beam intensity).

If $n_2>0$, it means that due to higher central intensity, the refractive index is also higher in the central region. As a result, the beam converges toward the center — this is known as the Kerr effect. However, the Kerr effect does not occur at all times. Self-focusing happens only when the power of the laser beam exceeds a certain critical threshold. This threshold is called the critical power, and it is defined as follows:

$$P_{cr} = \frac{3{,}77\lambda^2}{8\pi n_0 n_2} \quad (4)$$

If the laser beam power $P>P_{cr}$ the beam undergoes focusing.

By using numerical methods through computer modeling of the Nonlinear Schrödinger Equation (NLSE), we can study how high-power laser beams propagate in a nonlinear medium. To accomplish this, we use the Python programming language. With the help of Python, we rewrite Equation (1) for the one-dimensional case.

$$i\frac{\partial A}{\partial z} + \frac{1}{2k_0}\frac{\partial^2 A}{\partial x^2} + \gamma|A|^2 A = 0 \quad (5)$$

In Equation (5)

k_0 – Diffraction coefficient (a smaller value results in reduced diffraction and stronger focusing);

γ – Nonlinearity coefficient (a larger value leads to stronger focusing);

$A_0(x)$ – Initial beam amplitude (a higher value increases the focusing effect).

Analysis and Results

To model and study Equation (5), we write the following code in Python:

```
import numpy as np
import matplotlib.pyplot as plt
lambda0 = 1.0
n0 = 1.45
n2 = 2.0e-20
A0 = 1.0
w0 = 5.0
dx = 0.1  # (spatial step)
dz = 0.05  # (propagation step)
L = 200  # (spatial dimensionda)
T = 10
N = int(L / dx)
M = int(T / dz)
x = np.linspace(-L/2, L/2, N)
A_init = A0 * np.exp(-x**2 / (2 * w0**2))
def split_step_fourier(A, n2, dz, dx):
        A = np.fft.fft(A)
    kx = np.fft.fftfreq(len(A), dx) * 2 * np.pi
```

```
    A = np.fft.ifft(A * np.exp(-1j * kx**2 * dz / 2))
    # (self-focusing)
    A = A * np.exp(-1j * n2 * np.abs(A)**2 * dz)
    A = np.fft.fft(A)
    A = np.fft.ifft(A * np.exp(-1j * kx**2 * dz / 2))
    return A
A = A_init
intensity = []
for i in range(M):
    A = split_step_fourier(A, n2, dz, dx)
    intensity.append(np.abs(A)**2)
# Displaying the results in a graph
intensity = np.array(intensity)
plt.figure(figsize=(10, 6))
for i in range(0, M, int(M / 10)):
    plt.plot(x, intensity[i], label=f'Z = {i*dz:.2f}')
plt.xlabel('X (cm)')
plt.ylabel('Intensity (a.u.)')
plt.title('Self-focusing of High Power Laser Pulse in Dielectric Medium')
plt.legend()
plt.grid(True)
plt.show()
```

The results obtained from the 1D modeling are shown in Figure 1.

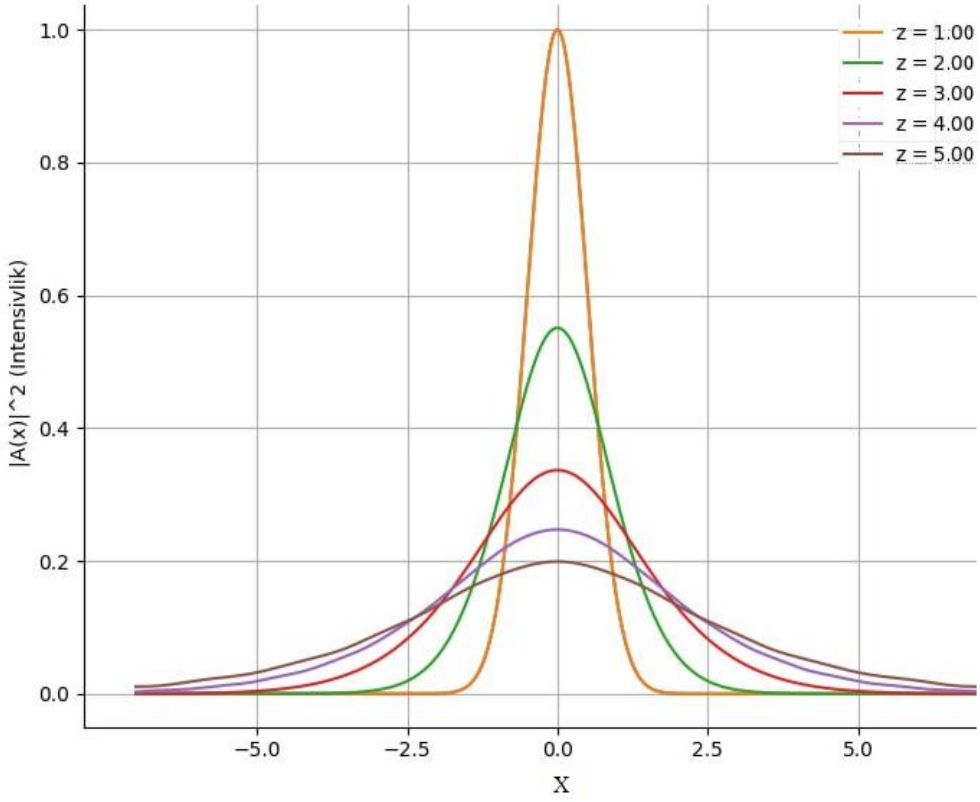

Figure 1. Self-focusing effect of high-power laser beams in a nonlinear dielectric medium.

Conclusion

The obtained results show that it is possible to model and study the self-focusing effect of high-power laser beams in a nonlinear dielectric medium based on mathematical equations describing the process. To achieve this, it is necessary to formulate the mathematical equations that fully represent the process and correctly define the boundary conditions. Then, using a Python program, the simulation process is implemented. By varying essential parameters like γ and k_0, it is possible to determine the optimal values of γ and k_0 that enhance the self-focusing effect.

References:

[1] Boyd R.W. "Nonlinear Optics," 4th ed., *Academic Press*, 2020.
[2] Agrawal G.P. "Nonlinear Fiber Optics," 6th ed., *Academic Press*, 2019.
[3] Kivshar Y.S., & Agrawal G.P. "Optical Solitons: From Fibers to Photonic Crystals," *Academic Press*, 2003.
[4] Molavi Choobini A.A., & Ghaffari-Oskooei S.S. "Investigation of self-focusing of Gaussian laser beams within magnetized plasma via source-dependent expansion method," 2024.
[5] Liu F., Xi T., Zhang L., & Hao Z. "Numerical simulation study on distinguishing nonlinear propagation regimes of femtosecond pulses in fused silica," *Scientific Reports*, 14, 2024, p. 5824.
[6] Molavi Choobini A.A., & Ghaffari-Oskooei S.S. "Investigation of self-focusing of Gaussian laser beams within magnetized plasma via source-dependent expansion method," *Physics of Plasmas*, 31(8), 2024, p. 082105.
[7] Lushnikov P. "Self-focusing and collapses of laser beams in nonlinear optical media," *OSE Seminar*, University of New Mexico, 2025.

UDC: 5, 502, 519.85, 004.822

A MATHEMATICAL INVESTIGATION OF THE PROCESSES OF SALT AND MOISTURE DISTRIBUTION IN SOIL BASED ON A CROSS-DIFFUSION MODEL

Muminov Sokhibjan Yunusovich
PhD, Department of General Professional Sciences, Mamun University
sokhibjan.muminov@gmail.com

Annotatsiya. Ushbu maqolada tuproq muhitida namlik va tuzning birgalikda tarqalish jarayonlari kross-diffuziya tizimi asosida matematik jihatdan modellashtirilgan. Tuproqdagi ikkilamchi sho‘rlanish va suv-tuz muvozanatining buzilishi kabi dolzarb muammolar nazariy va amaliy jihatdan yoritilgan. Model asosida namlik va tuz konsentratsiyasi o‘rtasidagi nochiziqli o‘zaro ta’sirlar ifodalangan. Amaliy misollar, jumladan sug‘oriladigan yerlar uchun olib borilgan holatlar orqali taklif etilgan modelning prognozlashdagi samaradorligi asoslangan. Tadqiqot natijalari barqaror suv-yer resurslarini boshqarish strategiyalarini ishlab chiqishda muhim ahamiyat kasb etadi.

Kalit so‘zlar: *kross-diffuziya, tuproq sho‘rlanishi, namlik tarqalishi, matematik modellashtirish, avtomodel yechimlar, tuproq fizikasi, suv-tuz balansi,*

noaniqlik tahlili, sug‘oriladigan yerlar, tuproq degradatsiyasi, chegara shartlari, ekologik barqarorlik.

Аннотация. В статье рассматривается математическое моделирование процессов совместного переноса влаги и солей в почвенной среде на основе системы кросс-диффузионных уравнений. Приведён обзор актуальности проблемы засоления и вторичного нарушения водно-солевого баланса в условиях сельскохозяйственного землепользования. На основе теоретической модели получены обобщённые зависимости, описывающие нелинейное взаимодействие между влагосодержанием и концентрацией растворённых солей. Проведён анализ практических кейсов, включая оросительные системы, и продемонстрирована эффективность предложенной модели при прогнозировании пространственно-временного распределения влаги и засоления. Полученные результаты обосновывают необходимость дальнейшего совершенствования методов устойчивого управления почвенно-гидрологическими условиями.

Ключевые слова: *кросс-диффузия, засоление почв, распределение влаги, математическое моделирование, автомодельные решения, физика почв, водно-солевой баланс, анализ неустойчивости, орошаемые земли, деградация почв, граничные условия, экологическая устойчивость.*

Abstract. This paper presents a mathematical modeling approach for simulating coupled salt and moisture transport in soil using a cross-diffusion system of equations. The study highlights the relevance of salinization and the disruption of the water-salt balance in agricultural land. The developed model captures the nonlinear interactions between moisture content and salt concentration, enabling the prediction of their spatial and temporal dynamics. Through practical case studies, including irrigated areas, the model's effectiveness is demonstrated in forecasting soil salinity and guiding sustainable soil and water management strategies.

Keywords: *cross-diffusion, soil salinization, moisture distribution, mathematical modeling, self-similar solutions, soil physics, water-salt balance, uncertainty analysis, irrigated lands, soil degradation, boundary conditions, environmental sustainability.*

Introduction

The study of the processes of distribution of moisture and salts in the soil plays a key role in understanding the productivity of agriculture and ensuring the environmental sustainability of agricultural landscapes. These processes directly affect such important parameters as plant health, moisture availability, preservation of soil structure and fertility. Therefore, a comprehensive and in-depth analysis of the patterns of their interrelations and distribution mechanism is necessary.

Mathematical modeling, in particular cross-diffusion models, is an effective tool for analyzing complex interdependencies between salt concentrations and moisture in different soil-climatic conditions. The use of phenomenological equations describing the coupled transfer of heat and moisture allows us to describe the dynamic behavior

of the soil system under real agro technical and hydrogeological factors, as discussed in detail in the study [1].

Additionally, the use of the one-dimensional form of the Richards equation allows modeling the absorption of moisture into the soil taking into account the growth of the root system of plants, which makes it possible to identify patterns of water absorption confirmed by empirical observations. Such approaches, in particular, are presented in the study [2].

Thus, the construction of a rigorous theoretical model creates the prerequisites not only for predicting soil behavior, but also for improving land reclamation technologies and geoengineering solutions aimed at increasing the efficiency of water use and restoring saline lands.

Literature Review

Various studies have investigated moisture and salt transport in irrigated soils, focusing on the impacts of salinization, irrigation regimes, and soil-water interactions. Many researchers have emphasized the need for accurate models to assess these processes under changing climatic and agricultural conditions.

Early studies explored practical tools for protecting water quality in agricultural landscapes using GIS-based planning and soil property estimation techniques [1, 2]. As the complexity of water-salt interactions became more evident, researchers began developing more advanced models. Cross-diffusion models, in particular, have received growing attention due to their ability to describe the coupled behavior of moisture and salts in partially saturated soils [3, 4].

In Uzbekistan, a number of works have focused on analytical solutions of nonlinear differential equations related to diffusion and cross-diffusion in soil environments [5–7]. These studies offered a theoretical basis for modeling moisture-salt dynamics, often with automodel approaches. More recently, this modeling framework has been expanded to describe more general planetary and geophysical environments, such as coastal aquifers and extraterrestrial terrains [8, 11].

Empirical validation of these models is presented in several regional studies. For instance, in the Murrumbidgee Irrigation Area of Australia, researchers used hydrological modeling to assess the impact of irrigation on groundwater salinity. The model showed up to 80% accuracy when evaluating variations in irrigation, rainfall, and evaporation [9]. Another study confirmed that salt accumulation severely affects both soil health and crop productivity, especially under different irrigation patterns [10].

Several investigations have also explored subsurface contributions to salinity [12], and the role of managed aquifer recharge through floodwater capture to reduce salinity risks [13]. These studies reflect the practical need for predictive modeling in designing sustainable irrigation systems.

Recent work by Muhamediyeva, Muminov, and colleagues has contributed to numerical modeling techniques for cross-diffusion processes, including boundary value problems, finite-difference schemes, and stability analysis [14–16]. These studies demonstrate the integration of mathematical theory and computational tools to support better decision-making in soil and water management.

Overall, the literature supports the view that cross-diffusion models are essential tools for understanding and managing the complex interaction of water and salt in agricultural soils. Both theoretical and practical investigations confirm their usefulness in mitigating salinization and improving irrigation efficiency.

Research Methodology

The actuality of studying the distribution of moisture and salts in the soil. Understanding the processes of distribution of moisture and salts in the soil is of paramount importance both for increasing agricultural productivity and for ensuring the environmental sustainability of land resources. Excessive accumulation of salts in the upper soil layers can significantly slow down plant growth, reduce crop yields and disrupt the natural soil balance. Studying these processes allows us to develop effective measures to prevent and mitigate the effects of salinization, especially in arid and semi-arid climates.

In this regard, mathematical models based on the cross-diffusion mechanism are an important tool for describing complex and interdependent processes of moisture and salt transfer in the soil environment. This approach, as shown in the study [3], provides a more accurate prediction of soil behavior under various moisture and salinity regimes.

Thus, an in-depth mathematical study of the distribution of moisture and salts in the soil contributes to the formation of scientifically based approaches to rational land use, as well as to the development of methods for sustainable management of soil and water resources in agriculture.

Theoretical foundations of the cross-diffusion model. The theoretical concept of the cross-diffusion model is the most important basis for analyzing the interrelated processes of salt and moisture distribution in the soil. Unlike traditional diffusion models, which describe the transfer of substances as independent processes, the cross-diffusion model takes into account the influence of the concentration gradient of one component on the flow of another. This is especially relevant when studying the dynamics of soil moisture and salts under conditions of uneven moisture, salinization, and variable climate.

The integration of moisture and salt transfer mechanisms within a single mathematical model allows for a detailed analysis of how changes in humidity affect salt migration, and vice versa — how salt concentration changes the moisture-retaining properties of the soil environment. This interdependent nature of transfer was substantiated in [4], where the importance of cross-modeling in describing processes in multicomponent porous media is emphasized.

Additionally, the application of this model allows us to identify statistically significant parameters of spatial variability of humidity and salt concentration, which is of practical value in monitoring the state of soils and managing the water-salt regime on agricultural lands. Thus, the cross-diffusion model serves not only as an analytical tool, but also as an applied mechanism in the tasks of forecasting and optimizing agro ecological systems.

Mathematical basis of the cross-diffusion model. The mathematical description of cross-diffusion processes is based on a system of coupled partial differential equations,

in which each flow depends not only on its own concentration gradient, but also on the gradient of the conjugate substance. In soil conditions, this means that the moisture flow can be induced by the salt gradient, and vice versa - the transport of salts can change depending on the moisture distribution. Such cross-interaction underlies models based on the principles of irreversible thermodynamics.

The classical form of the model is written as a system of two equations:

$$\begin{cases} \dfrac{\partial u_1}{\partial t} = \nabla(D_1 u_2^{m_1-1} \left|\nabla u_1^k\right|^{p-2} \nabla u_1) - v_1 u_2^{\beta_1} \left|\nabla u_1\right|^{p_1} \\ \dfrac{\partial u_2}{\partial t} = \nabla(D_2 u_1^{m_2-1} \left|\nabla u_2^k\right|^{p-2} \nabla u_2) - v_2 u_1^{\beta_2} \left|\nabla u_2\right|^{p_2} \end{cases} \quad (1)$$

In model (1) $u_1(x,t)$ and $u_2(x,t)$ respectively denote the moisture content and salt concentration in the soil, D_1, D_2 — are the diffusion coefficients, and v_1, v_2 - are the reaction intensity coefficients. All parameters of the model reflect the most important physical features of the interconnected processes in the soil environment.

m_i $(i=1,2)$ characterizes the change in the diffusion rate depending on the intercomponent dependence, and also determines, processes in salinity zones are strengthened or weakened. This is especially important for describing the dynamics of moisture-ion exchange in soils with a variable degree of saturation. p_i $(i=1,2)$ determines the degree of nonlinearity of the Laplace operator and reflects the sensitivity of the substance to the gradient along spatial coordinates. Its value affects the nature of the transfer in the presence of sharp changes in concentration.

The index k determines the degree of influence of the gradient intensity on the diffusion process and plays a key role in taking into account zonal differences within the studied area. It enhances the spatial selectivity of transfer and facilitates accurate modeling of frontal transitions.

The parameters β_i $(i=1,2)$ characterize the nonlinearity of the reaction interaction, determining the degree of influence of one component on another. Its change allows taking into account the complex mechanisms of interaction between salt and moisture under conditions of uneven distribution.

p_i $(i=1,2)$ describes the sensitivity of reaction terms to the gradient and reflects the influence of zonal changes in intensity on the kinetics of the process. It is especially important when modeling the dynamics in transition zones and in the presence of sharp boundaries between media.

In combination, the coefficients v_1 and v_2, characterizing the intensity of the reaction, link the speed and direction of processes with the physical and geographical features of a specific modeling area. This ensures the reproduction of zonal changes in moisture and salt flows, the dynamics of salt front migration, and the assessment of the speed characteristics of the processes under study in degrading soils.

A detailed qualitative analysis of such models was carried out by the author in works [5-6], where the properties of self-similar solutions, the conditions for their existence

and the asymptotic behavior of solutions under various soil saturation and salinization regimes were considered. Also, a significant contribution to the development of the theory of cross-diffusion models was made in the work [7], where a theoretical analysis of the stability and continuity of solutions depending on the characteristics of the environment was carried out.

Thus, the cross-diffusion model has the necessary level of mathematical rigor and physical interpretability, allowing one to describe complex processes of moisture and salt transfer in degrading soil systems.

Analysis and Results

Application of the cross-diffusion model in soil science. The cross-diffusion model has proven itself as an effective tool for studying the interrelated processes of moisture and salt transfer in various types of soils. By taking into account the cross-influence of moisture distribution and the concentration of dissolved salts, this model allows for more accurate prediction of the behavior of the soil environment under changing climatic and agrotechnical conditions. This is especially relevant in the context of secondary salinization problems resulting from irrational irrigation, disruption of natural drainage, and fluctuations in groundwater levels.

The use of the cross-diffusion model makes it possible to describe the interaction of zones with high humidity and salinity, which, in turn, allows us to quantitatively assess the degree of soil degradation and its impact on plant growth. Excessive accumulation of salts in the root-inhabited horizon leads to osmotic stress in agricultural crops, reduced yields, and disruption of microbiological activity. In this context, modeling such phenomena acquires practical significance in the tasks of sustainable land use.

The flexibility of the model is also demonstrated by the possibility of its adaptation to various research scales – from micro profile to regional agricultural landscape. As indicated in the work [3], the cross-diffusion model is successfully used to analyze the distribution of moisture and dissolved substances in porous media. Moreover, individual components of this model can be integrated into multi-component climate and hydrogeological simulators, including the ROCKE-3D atmospheric layer models used to study planetary atmospheres, which opens up prospects for cross-disciplinary research [8].

Model Efficiency: Examples and Empirical Studies. The results of the practical application of the cross-diffusion model are confirmed by a number of case studies, which demonstrated its ability to accurately reproduce the spatio-temporal distribution of moisture and salts. Thus, in a study conducted in the Murrumbidgee irrigation system (Australia), the model was successfully used to analyze groundwater dynamics under rice cultivation conditions. High accuracy (up to 80%) was achieved in predicting the behavior of the aquifer when varying input parameters such as precipitation, irrigation regime, and evaporation [9].

This study demonstrated how salinization processes are aggravated during the growing season, when the groundwater level rises and dissolved salts migrate to the active zone of the root system. This approach also allows for seasonal dynamics to be taken into account and the impact of anthropogenic factors on the water-salt balance to be assessed.

Additionally, in the study [10], it is shown that salt accumulation has a critical impact on the agroecosystem as a whole. Here, the cross-diffusion model serves as both an analytical and prognostic tool for identifying risk zones and developing measures to improve soil conditions.

Thus, the practical application of the cross-diffusion model confirms its high adaptability and accuracy in analyzing complex interactions between moisture and salts in soil systems. This makes it an indispensable element of scientifically based land use and sustainable water management.

The conducted analysis of the distribution of moisture and salts in the soil based on the cross-diffusion model demonstrated the complex nature of the interaction between hydrodynamic processes and the transport of dissolved substances. Mathematical modeling, taking into account the influence of such physical factors as evaporation, infiltration and external loads, made it possible to identify the significant influence of these parameters on intrasoil flows and the formation of salt profiles. The results of the study show that the relationship between humidity and salt concentration is not linear, but strongly dependent on environmental conditions. For example, as shown in [11], wave processes can significantly change the trajectories of salt movement and their retention time in coastal zones. This emphasizes the importance of a comprehensive approach to the analysis of deep processes that determine salinization.

In addition, the study of soil salinity control mechanisms points to the need to develop effective water management strategies, especially in arid and irrigated regions. As noted in the study [12], a significant proportion of salt pollution is formed not by surface runoff, but as a result of complex subsurface processes occurring in the capillary active zone.

Thus, the cross-diffusion model, with high sensitivity to the physicochemical characteristics of the environment, provides a reliable tool for predicting and preventing soil salinization, as well as for optimizing irrigation systems and sustainable land use.

Conclusion

The results obtained confirm the need to introduce innovative approaches to soil management in agricultural practice, especially in conditions of secondary salinization and climatic instability. Excessive accumulation of salts has a destructive effect on crop productivity and the biological state of the soil, which requires a comprehensive understanding of the associated dynamic processes.

Further research should be aimed at developing more accurate continuity equations and models of moisture-salt interactions at various scales, from microscopic to landscape. Particular attention should be paid not only to zones with pronounced salinization, but also to subclinical forms of secondary salinization, common in conditions of insufficient drainage and unstable meteorological conditions [10].

Another promising direction is the practice of On-Farm Flood Flow Capture, as proposed in [13], which considers the use of agricultural land to intercept flood waters and replenish underground aquifers while simultaneously controlling salinity.

Continuing research in these areas is important to improve the resilience of agriculture to climate risks and ensure long-term soil fertility.

References:

[1] Babcock B.A., Pautsch G.R., Tyndall J.C. “Using GIS to Determine Cost Effective Buffers for Water Quality Protection in Agricultural Landscapes,” *Journal of Soil and Water Conservation,* Vol. 56, № 1, 2001, pp. 44–48.

[2] Ali M., Matsumoto T., Inoue M. “Estimation of hydraulic properties of a sandy loam soil using the unsaturated infiltration method,” *Agricultural Water Management,*Vol. 65, 2004, pp. 133–143. DOI: 10.1016/j.agwat.2003.09.002

[3] Cassi D., Schrefler B.A., Ferraris L. “Cross-diffusion models for heat and mass transfer in partially saturated soils,” *Transport in Porous Media*. Vol. 124, 2018, pp. 589–606. DOI: 10.1007/s11242-018-1065-9

[4] Scarfato P., Avallone E., Di Maio L. “Coupled transport phenomena in porous media: modeling moisture and salt migration,” *Journal of Hydrology*. Vol. 585, 2020, p. 124776. DOI: 10.1016/j.jhydrol.2020.124776

[5] Muminov S.Y. “Self-similar solutions of nonlinear parabolic-type differential equations for modeling diffusion processes,” *Bulletin of Agricultural Science of Uzbekistan*, № 4(10), 2023, pp. 89–95.

[6] Muminov S.Y. “Self-similar solutions of a system of nonlinear cross-diffusion differential equations,” *Problems of Computational and Applied Mathematics*, № 4(51), 2023, pp. 53–58.

[7] Muminov S., Agarwal P., Muhamediyeva D. “Qualitative properties of the mathematical model of nonlinear cross-diffusion processes,” *Nanosystems: Phys. Chem. Math.* Vol. 15, № 6, 2024, pp. 742–748. DOI: 10.17586/2220-8054-2024-15-6-742-748

[8] Aleinov I., Kiang N.Y., Kelley M., Roman M. et al. ”Modeling planetary environments with the ROCKE-3D GCM,” *The Astrophysical Journal Supplement Series*. Vol. 241, № 1, 2019, p. 24. DOI: 10.3847/1538-4365/ab03ea

[9] Abbas A., Khan S., Rana T., Mushtaq S. “Hydrological modeling to assess the impact of irrigation on groundwater salinization in the Murrumbidgee Irrigation Area,” *Agricultural Water Management*, Vol. 128, 2013, pp. 85–93. DOI: 10.1016/j.agwat.2013.06.004

[10] Hassani A., Ebrahimi M., Pahlavan-Rad M. “Modeling salt accumulation and its effect on soil and crop productivity under different irrigation regimes,” *Environmental Monitoring and Assessment*. Vol. 192, 2020, p. 98. DOI: 10.1007/s10661-019-8021-9

[11] Geng X., Wilson A.M., Michael H.A. “Impact of oceanic wave dynamics on subsurface solute transport in coastal aquifers,” *Water Resources Research*. Vol. 56, № 5, 2020, p. e2019WR026915. DOI: 10.1029/2019WR026915

[12] Bhasker U., Rao Y.S., Srinivas K. “Modelling salinity sources in irrigated regions: Subsurface contributions,” *Agricultural Water Management*. Vol. 187, 2017, pp. 104–113. DOI: 10.1016/j.agwat.2017.04.015

[13] Bachand P.A.M., Horwath W.R., Roy S.B. “Using on-farm flood capture to recharge groundwater and mitigate salinity,” *Journal of Environmental Management*. Vol. 144, 2014, pp. 113–122. DOI: 10.1016/j.jenvman.2014.05.013

[14] Muhamediyeva D.K., Nurumova A.Yu., Muminov S.Y. “Cauchy Problem and Boundary-Value Problems for Multicomponent Cross-Diffusion Systems,” *International Conference on Information Science and Communications Technologies, ICISCT 2021*, Tashkent, November 2021. DOI: 10.1109/ICISCT52966.2021.9670380

[15] Muhamediyeva D.K., Nurumova A.Yu., Muminov S.Y. “Numerical modeling of cross-diffusion processes,” *E3S Web of Conferences*, 401, 2023, pp. 05060. DOI: 10.1051/e3sconf/202340105060

[16] Muhamediyeva D.K., Muminov S., Shaazizova M.E., Hidirova Ch., Bahromova Yu. “Limited different schemes for mutual diffusion problems,” *E3S Web of Conferences*, 401, 2023, pp. 05057 DOI: 10.1051/e3sconf/202340105057

UDC: 53, 620, 327

A COMPARATIVE ANALYSIS OF HYDROGEN TECHNOLOGY DEVELOPMENT IN SOUTH KOREA AND ITS APPLICABILITY TO UZBEKISTAN

Nosir Matyakubov
Associate Professor (PhD), Department of Physics, Urgench State University named after Abu Rayhan Biruni
nosirbek0726@gmail.com

Diyorbek Isayev
Department of Physics, Urgench State University named after Abu Rayhan Biruni

Jamila Madrakhimova
Department of Physics, Urgench State University named after Abu Rayhan Biruni

Mukhtorjon Karimov
Associate Professor (PhD), Department of Physics, Urgench State University named after Abu Rayhan Biruni

Annotatsiya. Vodorod energetikasi texnologiyalarini rivojlantirish global sur'atga ega bo'ldi, chunki mamlakatlar an'anaviy qazib olinadigan yoqilg'ilarga barqaror va past uglerodli muqobillarni qidirmoqdalar. Ushbu maqolada Janubiy Koreyada vodorod texnologiyasi rivojlanishining qiyosiy tahlili va uning O'zbekistonda rivojlanayotgan energetika sektorida qo'llanilishi ko'rsatilgan. Janubiy Koreyaning strategik yo'l xaritasi, tadqiqot va ishlanmalarga kuchli investitsiyalar va faol sanoat ishtiroki uni vodorod innovatsiyalari bo'yicha global yetakchiga aylantirdi. Bundan farqli o'laroq, O'zbekiston vodorodga o'tishning yangi bosqichida, qiziqish ortib bormoqda, lekin cheklangan infratuzilma va siyosat asoslari. Ushbu tadqiqotda koreys vodorod texnologiyalarining O'zbekiston sharoitiga o'tkazuvchanligini baholash uchun keng qamrovli adabiyotlarni ko'rib chiqish, siyosat tahlili va amaliy tadqiqotlarni o'z ichiga olgan aralash usulli yondashuv qo'llaniladi. Natijalar shuni ko'rsatadiki, bir qancha Koreya texnologiyalari, xususan, elektroliz va yonilg'i xujayrasi tizimlari orqali vodorod ishlab chiqarish O'zbekistonning qayta tiklanadigan energiya salohiyatiga texnik jihatdan mos keladi.

Kalit so'zlar: *Vodorod energiyasi, Texnologiyalar transferi, Qayta tiklanadigan energiya integratsiyasi, Siyosat va infratuzilma, Janubiy Koreya-O'zbekiston hamkorligi.*

Аннотация. Развитие водородных энергетических технологий получило глобальный импульс, поскольку страны ищут устойчивые и низкоуглеродные альтернативы традиционным ископаемым видам

топлива. В этой статье представлен сравнительный анализ развития водородных технологий в Южной Корее и их применимости к формирующемуся энергетическому сектору в Узбекистане. Стратегическая дорожная карта Южной Кореи, надежные инвестиции в исследования и разработки и активное участие промышленности позиционировали ее как мирового лидера в области водородных инноваций. Напротив, Узбекистан находится на начальной стадии своего перехода на водород с растущим интересом, но ограниченными инфраструктурой и политическими рамками. В этом исследовании используется смешанный методический подход, включая обширный обзор литературы, анализ политики и изучение тематических исследований, для оценки переносимости корейских водородных технологий в узбекский контекст. Результаты показывают, что несколько корейских технологий, особенно в производстве водорода с помощью электролиза и систем топливных элементов, технически совместимы с потенциалом возобновляемой энергии Узбекистана.

Ключевые слова: *водородная энергетика, передача технологий, интеграция возобновляемой энергии, политика и инфраструктура, сотрудничество Южной Кореи и Узбекистана.*

Abstract. The development of hydrogen energy technologies has gained global momentum as countries seek sustainable and low-carbon alternatives to conventional fossil fuels. This paper presents a comparative analysis of hydrogen technology development in South Korea and its applicability to the emerging energy sector in Uzbekistan. South Korea's strategic roadmap, robust investment in research and development, and active industrial participation have positioned it as a global leader in hydrogen innovation. In contrast, Uzbekistan is at a nascent stage in its hydrogen transition, with growing interest but limited infrastructure and policy frameworks. This study employs a mixed-method approach, including an extensive literature review, policy analysis, and examination of case studies, to evaluate the transferability of Korean hydrogen technologies to the Uzbek context. The findings indicate that several Korean technologies, particularly in hydrogen production via electrolysis and fuel cell systems, are technically compatible with Uzbekistan's renewable energy potential.

Keywords: *Hydrogen Energy, Technology Transfer, Renewable Energy Integration, Policy and Infrastructure, South Korea-Uzbekistan Collaboration.*

Introduction

Hydrogen energy has emerged as a key component in the global transition toward low-carbon and sustainable energy systems. Recognized for its potential to decarbonize hard-to-abate sectors such as transport, industry, and power generation, hydrogen offers both environmental and strategic energy security benefits. As countries worldwide commit to carbon neutrality targets, the development and deployment of hydrogen technologies have become central to energy policy agendas, research initiatives, and industrial investments [1-3]. South Korea is at the forefront of this global shift. With the announcement of its Hydrogen Economy Roadmap in 2019 and subsequent legislative support, South Korea has established itself as a leader in

hydrogen innovation. The country has made significant advances in hydrogen production, fuel cell technology, and infrastructure development, supported by both government policies and private sector initiatives. South Korea's experience presents a comprehensive model of a coordinated hydrogen strategy that integrates technological innovation with policy support and market creation [5-7].

In contrast, Uzbekistan is in the early stages of exploring hydrogen energy as part of its broader energy diversification and decarbonization efforts. With abundant renewable resources such as solar and wind, Uzbekistan holds substantial potential for green hydrogen production. Recent national policies and international partnerships indicate a growing interest in leveraging hydrogen as a future energy vector. However, the country faces challenges related to technological readiness, infrastructure limitations, and policy alignment.

This paper aims to conduct a comparative analysis of hydrogen technology development in South Korea and assess its applicability to Uzbekistan's evolving energy landscape. The study draws on literature review, policy documents, and relevant case studies to identify areas of technological compatibility and strategic collaboration.

Literature Review

Hydrogen Technology Development in South Korea. South Korea has positioned itself as a global frontrunner in the development and deployment of hydrogen technologies. The country's strategic commitment to hydrogen began with the announcement of its Hydrogen Economy Roadmap in 2019, which set ambitious targets for production, utilization, and infrastructure expansion through 2040. The roadmap outlines a vision to establish a hydrogen-powered society by fostering technological innovation, encouraging industrial participation, and enabling supportive legislation [1,2,8].

Technological Innovations and Industry Participation. South Korea's technological development has been marked by significant progress in hydrogen production, storage, and utilization. In the area of production, research and commercial initiatives have focused on water electrolysis, steam methane reforming (SMR) with carbon capture, and by-product hydrogen recovery from industrial processes. For storage and transport, advanced hydrogen compression, liquefaction, and pipeline systems have been developed.

Fuel cell technology has seen particularly rapid growth. Companies such as Hyundai, Doosan Fuel Cell, and POSCO Energy have been instrumental in advancing both mobility and stationary power generation applications. Hyundai's deployment of the NEXO FCEV and its investment in hydrogen-powered trucks and ships signal a deep industrial commitment to hydrogen mobility.

Research and Development Ecosystem. South Korea's hydrogen innovation ecosystem is supported by national research institutes (e.g., KIER – Korea Institute of Energy Research), universities, and industry-academia consortia. Government R&D funding has focused on improving efficiency, reducing costs, and scaling up key hydrogen technologies. The country's public-private model promotes collaborative R&D, demonstration projects, and commercialization initiatives.

International Collaborations. Recognizing the global nature of hydrogen development, South Korea has actively sought international partnerships to secure hydrogen supply chains and exchange technical expertise. Bilateral agreements with countries such as Australia, the UAE, and Saudi Arabia aim to establish long-term import corridors for clean hydrogen. This approach positions South Korea as both a hydrogen technology exporter and importer within the global market.

Current State of Hydrogen Energy in Uzbekistan. Uzbekistan's energy sector is undergoing a significant transformation, driven by the need to modernize infrastructure, reduce greenhouse gas emissions, and diversify its energy mix. The country has historically relied on fossil fuels, particularly natural gas, to meet domestic energy demands. However, in recent years, the government has initiated ambitious reforms to promote renewable energy and explore alternative energy vectors, including hydrogen.

National Energy Profile. Uzbekistan possesses substantial energy resources, including natural gas, oil, and coal, with natural gas accounting for a majority share of electricity generation. Despite this resource wealth, aging infrastructure and energy inefficiencies have prompted a reevaluation of long-term energy strategy. In alignment with the country's commitments under the Paris Agreement, Uzbekistan has set targets to increase the share of renewables in electricity generation to 25% by 2030.

Emerging Interest in Hydrogen Energy. Hydrogen energy has recently gained attention in Uzbekistan as a potential solution for decarbonizing industry and supporting the integration of intermittent renewables. While no large-scale hydrogen projects are currently operational, the government has included hydrogen in its Strategy for the Transition to a Green Economy (2019–2030) and its Renewable Energy Development Program. In 2022, Uzbekistan signed memoranda of understanding with international partners, including Korea and Japan, to conduct feasibility studies on hydrogen production. These initiatives highlight a growing institutional interest in assessing hydrogen's role in the future energy landscape.

Renewable Energy Potential. Uzbekistan's natural advantages-high solar irradiation and significant wind corridors-offer favorable conditions for green hydrogen production via water electrolysis powered by renewables. Several solar and wind power projects are already in development with support from international organizations such as the Asian Development Bank (ADB) and Masdar (UAE), laying the groundwork for integrated hydrogen systems.

Institutional and Technological Challenges. Despite these opportunities, Uzbekistan faces several barriers to hydrogen development. These include the absence of a hydrogen-specific regulatory framework, limited domestic technical expertise, lack of infrastructure for hydrogen transport and storage, and underdeveloped research and industrial capacity in this field. Furthermore, investments in hydrogen R&D remain limited, and there is a need for knowledge transfer and capacity building.

Research Methodology

This study employs a mixed-method approach, combining qualitative and quantitative analysis to assess the transferability of South Korea's hydrogen technologies to Uzbekistan.

Analysis and Results

Comparative Analysis. A comprehensive comparison between South Korea and Uzbekistan reveals significant asymmetries in the development, adoption, and readiness of hydrogen technologies. This section evaluates five key dimensions-technological readiness, infrastructure compatibility, research ecosystems, investment climates, and technical expertise-to assess the feasibility of transferring South Korean hydrogen technologies to the Uzbek context [2,5,7,8].

Technological Readiness-South Korea exhibits high technological readiness in hydrogen production, storage, distribution, and utilization. The country has developed commercial-scale electrolysis systems, fuel cell vehicles, hydrogen refueling stations, and stationary power units. By contrast, Uzbekistan is in the exploratory phase, with no commercially deployed hydrogen systems to date. While the country has favorable conditions for renewable-based hydrogen production, it lacks the necessary technological platforms and supply chain integration to operationalize hydrogen at scale.

Infrastructure and Grid Compatibility-Korea's hydrogen infrastructure includes a growing network of hydrogen refueling stations, dedicated hydrogen pipelines, and smart grid systems designed to accommodate hydrogen integration. The national grid has been gradually modernized to support distributed generation and renewable integration, facilitating hybrid systems that include hydrogen storage and backup.

In contrast, Uzbekistan's electricity grid remains largely centralized and reliant on natural gas-fired power plants. Limited flexibility, aging transmission networks, and the absence of hydrogen-specific infrastructure pose significant challenges. Substantial investment in grid modernization, digitalization, and hydrogen-compatible transport infrastructure would be required to ensure technical compatibility.

R&D Ecosystems and Innovation Policy-South Korea's R&D ecosystem is characterized by strong collaboration between government research institutions, universities, and industry. National funding programs, such as those from the Ministry of Trade, Industry and Energy (MOTIE), support pilot projects, commercialization efforts, and fundamental research in hydrogen science and engineering. Innovation policies are well-aligned with industrial objectives, ensuring technology diffusion and rapid deployment.

Uzbekistan, while making strides in renewable energy research, lacks a dedicated hydrogen R&D framework. Research institutions and universities have limited capacity in hydrogen-related disciplines, and coordinated national research programs are still under development. Collaboration with international partners could serve as a catalyst for building domestic R&D capacity.

Applicability and Transferability of Korean Technologies. The successful transfer of hydrogen technologies from South Korea to Uzbekistan depends on aligning technological solutions with Uzbekistan's specific energy needs, infrastructure capacity, and policy environment. While South Korea offers a broad spectrum of mature hydrogen technologies, only selected systems are currently suitable for implementation in Uzbekistan due to contextual differences in market readiness, regulatory maturity, and technical capacity [1,3,8].

Suitable Technologies for Uzbekistan-among the range of South Korean hydrogen technologies, alkaline and proton exchange membrane (PEM) electrolysis systems are particularly relevant to Uzbekistan, given the country's potential for solar and wind energy integration. These systems offer a feasible route for green hydrogen production, especially in areas with high solar irradiance such as the Navoi and Bukhara regions. Additionally, small- to medium-scale stationary fuel cells, already deployed in Korea for decentralized power generation, could be piloted in Uzbekistan for off-grid and industrial applications. Hydrogen storage and compression systems developed in South Korea also have strong applicability, particularly in the context of energy storage for renewable power plants. Their adoption in Uzbekistan would enable better load balancing and enhance the reliability of solar and wind power systems.

Case Studies and Proposed Pilot Projects-pilot projects play a critical role in demonstrating the feasibility of hydrogen technologies in a new context. A proposed project could involve the installation of a solar-powered electrolyzer in collaboration with a Korean manufacturer such as Doosan or Hanwha. The produced hydrogen could be used for mobility trials (e.g., hydrogen-powered buses) or in fertilizer production at existing chemical plants, given Uzbekistan's strong agricultural base.

Another viable pilot is the deployment of a fuel cell-based microgrid in a remote or industrial area, coupled with renewable generation. South Korea's experience with such projects in island regions and military facilities can provide a replicable model for Uzbekistan.

Potential Challenges in Adaptation-several barriers may hinder the adaptation of Korean hydrogen technologies in Uzbekistan. These include:

- High capital costs of advanced hydrogen systems and the absence of subsidies or financial incentives.
- Limited technical workforce, which constrains the operation and maintenance of imported technologies.
- Regulatory vacuum, including the lack of hydrogen-specific safety standards and fuel certification.
- Grid limitations, which may impede the integration of electrolyzers or distributed fuel cell systems.

To overcome these challenges, Uzbekistan will need to phase in hydrogen technologies through demonstration projects, create enabling policy instruments, and prioritize human resource development. Engagement with Korean industry and academic institutions can provide critical support for localized adaptation, technical training, and long-term sustainability.

Conclusion

This study has examined the development of hydrogen technologies in South Korea and assessed their applicability to the energy transition context in Uzbekistan. Through a comparative analysis, it has become evident that while South Korea has established a technologically advanced and policy-supported hydrogen economy, Uzbekistan is still in the early stages of exploring hydrogen as part of its green energy future.

Key findings indicate that several Korean technologies-particularly in the fields of water electrolysis, stationary fuel cells, and hydrogen storage-are technically and

environmentally suitable for deployment in Uzbekistan. However, significant disparities exist in infrastructure readiness, regulatory maturity, and human capital development. While Korea benefits from a coordinated innovation ecosystem and strong private-sector engagement, Uzbekistan faces challenges related to investment mechanisms, institutional capacity, and knowledge transfer.

In conclusion, aligning Uzbekistan's renewable energy ambitions with South Korea's technological expertise presents a mutually beneficial opportunity. As the global shift toward hydrogen accelerates, a well-coordinated partnership between these two nations could serve as a regional model for clean energy development, innovation, and sustainability.

References:

[1] Retrieved from IEA Policies "Hydrogen Economy Roadmap of Korea," *Ministry of Trade, Industry and Energy (MOTIE)*, Republic of Korea, 2019.
[2] Retrieved from IEA Hydrogen "Hydrogen," *International Energy Agency (IEA)*, 2023.
[3] Kan S. "South Korea's Hydrogen Strategy and Industrial Perspectives," *French Institute of International Relations (Ifri)*, Retrieved from Ifri Publication, 2020.
[4] Retrieved from Energy Partnership Korea "Status of Hydrogen and Potential for Cooperation," *Energy Partnership Korea*, 2023.
[5] Retrieved from Hydrogen Council Report "Hydrogen Insights 2022," *Hydrogen Council*, 2022.
[6] Retrieved from UNECE Report United Nations "Draft Roadmap for Production and Use of Hydrogen in Ukraine," *Economic Commission for Europe (UNECE)*, 2021.
[7] Retrieved from IEA Net Zero Report "Net Zero by 2050: A Roadmap for the Global Energy Sector," *International Energy Agency (IEA)*, 2021.
[8] Retrieved from National Hydrogen Strategy "National Hydrogen Strategy Update," *Energy Partnership Korea*, 2023.