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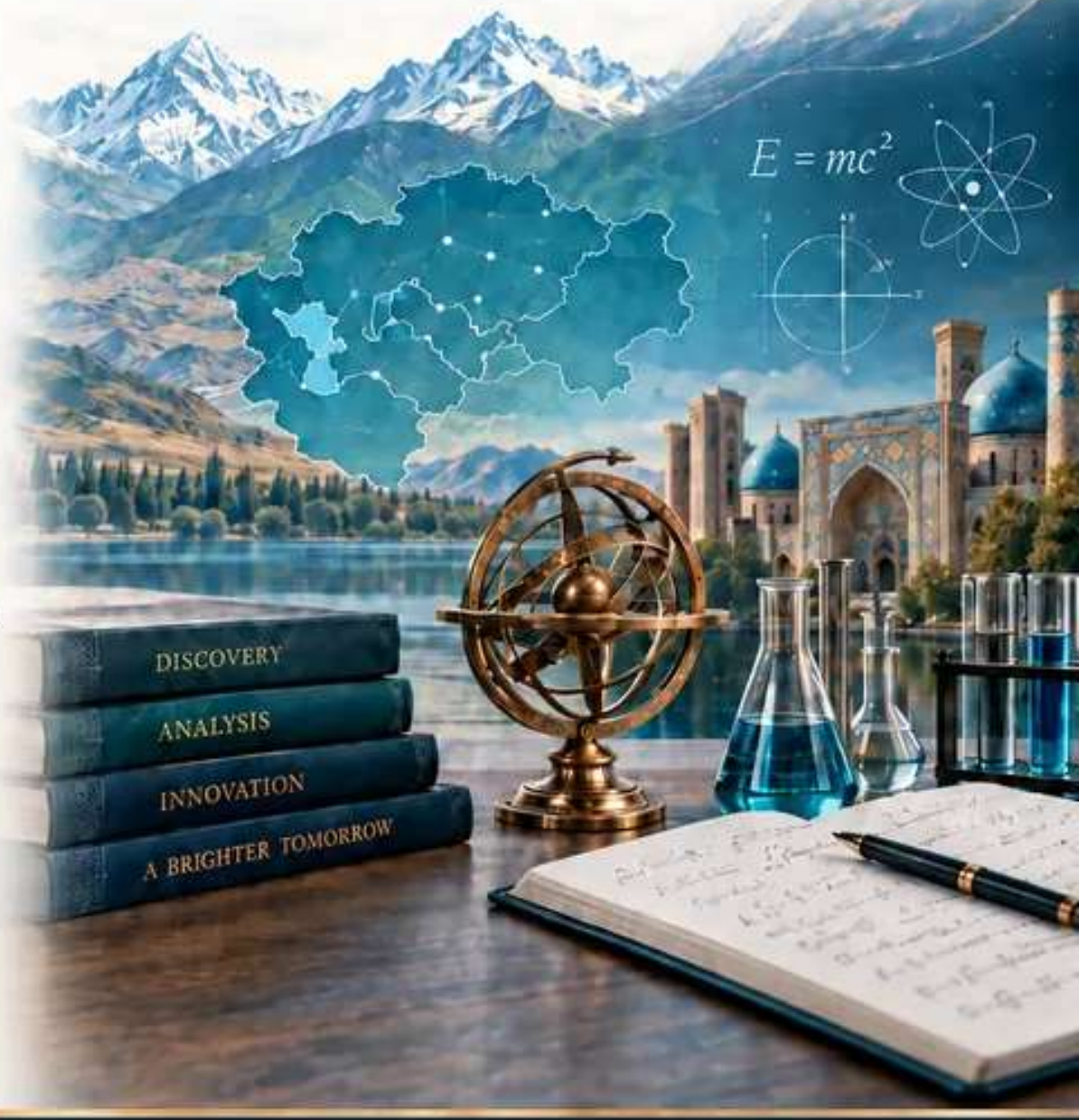
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Extraction of Technical Glycyrrhizic Acid from Licorice (Glycyrrhiza glabra L.) Root and Synthesis of Its Copper Supramolecular Complex

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Abstract

Licorice (Glycyrrhiza glabra L.), locally known as "boyan," is one of the most widely used medicinal plants of Central Asia, and its principal bioactive triterpene saponin, glycyrrhizic acid, is of substantial pharmacological and agrochemical interest. This study reports the extraction of technical glycyrrhizic acid from the thick aqueous extract of licorice root cultivated and growing wild in the central districts of the Republic of Karakalpakstan, its conversion to ammonium-salt derivatives, and the synthesis of a copper-containing supramolecular complex intended for use as an agricultural biostimulant. Technical glycyrrhizic acid was precipitated from the root extract with dilute sulfuric acid; systematic variation of the acid volume showed that the precipitation yield is strongly pH-dependent, reaching a maximum of 21.8% at pH ≈ 2.9, with an overall technical-acid yield of 35–40% relative to the starting extract. Acetone extraction followed by treatment with ammonia gave the triammonium salt (32% yield), which was further converted to the monoammonium salt (88% yield) by recrystallization from ethanol; the purified acid's melting point (222 ± 2 °C) and optical rotation ([α]D25 = +60 ± 2°) matched literature values. Potentiometric titration showed that a 97%-purity monoammonium salt sample contained close to the theoretical three free carboxyl groups per molecule, comparing favourably with a 75%-purity commercial reference preparation. The monoammonium salt was subsequently used to synthesize a copper supramolecular complex (CuproTGK) whose formation through host–guest, hydrogen-bonded, and hydrophobic interactions was confirmed by infrared spectroscopy. These results establish a reproducible, low-cost extraction and derivatization route to pharmaceutical- and agricultural-grade glycyrrhizic acid preparations from regionally grown licorice.

Keywords: glycyrrhizic acid, licorice, Glycyrrhiza glabra, supramolecular complex, copper complex, natural product extraction, host–guest chemistry

1. Introduction

The root of licorice (Glycyrrhiza glabra L.; "boyan" in Karakalpak and Uzbek, "solodka golaya" in Russian) has been used as a medicinal raw material for millennia, with documented use in Chinese medicine dating back some 2,800 years and detailed description in Avicenna's Canon of Medicine [2]. Among medicinal plants, licorice root occupies an especially broad range of therapeutic application, owing chiefly to its content of glycyrrhizic acid, a triterpene glycoside that can constitute up to 23% of the root's dry mass and that underlies the root's traditional use as an expectorant, an anti-inflammatory and antiulcer agent, a hepatoprotective and choleretic remedy, and an antidote in cases of food or snake-venom poisoning [2, 3, 11]. This broad pharmacological profile, combined with a favourable toxicological safety margin relative to many synthetic agents, has sustained continuous scientific interest in licorice-derived compounds [13, 14, 15, 16].

The flora of Karakalpakstan is unusually rich in medicinal herbs, and licorice, sometimes referred to locally as the "golden root" for its economic value, is a characteristic and abundant component of that flora, occurring extensively along the lower reaches of the Amu Darya and throughout the delta region [4, 5, 7]. Government policy has increasingly recognized this resource: the Presidential Decree of 10 April 2020, "On measures for the protection of wild-growing medicinal plants, their cultivation, processing, and rational use of available resources," and the earlier Resolution of the Cabinet of Ministers of 14 April 2017 encouraging licorice export, together with the Action Strategy for the Further Development of the Republic of Uzbekistan (2017–2021), have created considerable institutional momentum behind deeper local processing of licorice raw material rather than its export as unprocessed root [1]. More than ten joint ventures engaged in licorice processing have since been established in the Republic of Karakalpakstan, underscoring

both the commercial opportunity and the corresponding need for standardized, well-characterized extraction methodology suited to regionally grown raw material.

At the same time, the development of the chemical industry as one of the sectors underpinning national economic stability is closely tied to the extraction of natural compounds — alkaloids, antibiotics, vitamins, hormones, and enzymes — from local medicinal plant resources for use in chemical technology, pharmacology, the food industry, and agriculture. Natural compounds isolated from local raw material offer a route to environmentally benign agrochemical products capable of improving soil productivity and protecting crops from adverse growth factors, an objective of particular relevance in the saline-soil conditions that prevail across much of the Aral Sea region. Realizing this potential, however, first requires a reliable and economically viable method for extracting glycyrrhizic acid, in sufficient purity, from regionally sourced licorice root, and for converting it into derivatives, such as metal-ion supramolecular complexes, suited to specific pharmaceutical or agrochemical applications.

The present study addresses this need. Its aims were: (i) to extract technical glycyrrhizic acid from the thick aqueous extract of licorice root grown, both wild and under cultivation, in the central districts of the Republic of Karakalpakstan, and to determine the reaction conditions that maximize its yield; (ii) to convert the technical acid into its triammonium and monoammonium salts and to characterize the purified product against literature reference values and against a commercial licorice-derived pharmaceutical preparation; and (iii) to synthesize, from the purified glycyrrhizic acid derivative, a copper-containing supramolecular complex intended for subsequent evaluation as an agricultural biostimulant.

2. Literature Review

2.1. Botanical Distribution and Phytochemical Background of Licorice

Within Central Asia, Glycyrrhiza glabra L. is distributed across the Syr Darya, Zarafshan, Chirchiq, and Angren river basins, the lower Amu Darya, and the territories of Khorezm and Karakalpakstan, with its principal Amu Darya delta plantations belonging predominantly to this species [5, 8]. Geobotanical surveys of the lower Amu Darya region have characterized the plant's morphological structure, its ecological-phytocoenological affinities, and the composition of its natural formations, which in some surveyed areas have been shown to comprise as many as 27 families, 68 orders, and 99 species growing in association with licorice stands [5]. Comparable surveys in Turkmenistan, western Kazakhstan, and the Fergana Valley have documented the plant's biological properties and raw-material reserves and have informed methods for the cultivation and accelerated regeneration of licorice stands subject to anthropogenic pressure [6, 9, 12].

Phytochemically, glycyrrhizic acid is a triterpene saponin comprising a glycyrrhetinic acid aglycone linked to a diglucuronide moiety [17]; its salts and derivatives have been the subject of extensive pharmacological and structural characterization, including studies of membrane-active and interferon-inducing derivatives of glycyrrhetinic acid and of molecular complexes formed between the monoammonium salt of glycyrrhizic acid and various pharmaceutical agents [14, 15, 16]. This body of work establishes both the chemical versatility of the glycyrrhizic acid scaffold and the practical importance of reliable, reproducible methods for its extraction and purification from licorice root.

2.2. Extraction and Standardization of Glycyrrhizic Acid

The glycyrrhizic acid content of licorice root reported in the literature ranges from approximately 2% to 24% of dry mass, and a large number of extraction methods have been proposed, the majority of which rely on precipitating glycyrrhizic acid from an aqueous root extract using a mineral acid [10]. Muravyev and Ponomarev demonstrated the advantages of gravimetric, titrimetric, and chromatographic analytical methods for standardizing licorice root and its preparations against a defined content of pure glycyrrhizic acid, establishing an analytical framework subsequently adopted by later researchers, including the present study [10]. A central practical difficulty noted in this literature is that the choice of precipitating acid and its concentration strongly affects both the yield and the physical form of the precipitate: concentrated sulfuric acid precipitates the acid rapidly but yields a resinous mass heavily contaminated with ballast substances, whereas more dilute acid, added gradually, favours precipitation of the product in a cleaner, amorphous form.

Once isolated, technical glycyrrhizic acid is conventionally converted to its ammonium salts to facilitate further purification and characterization. Literature methods typically proceed via acetone extraction of the technical acid followed by treatment with concentrated aqueous ammonia to give the triammonium salt, which is subsequently converted, via reaction with glacial acetic acid and recrystallization from aqueous ethanol, to the more stable and pharmaceutically relevant monoammonium salt [10, 18]. Commercial preparations of the monoammonium salt — such

as “Gliciram,” produced by Chimkentbiofarm ICHB in the Republic of Kazakhstan — provide a useful benchmark of purity and physicochemical constants against which regionally extracted material can be compared.

2.3. Supramolecular Complexes of Glycyrrhizic Acid

Glycyrrhizic acid and its monoammonium salt are known to form molecular and supramolecular complexes with a range of guest molecules, including pharmaceutical agents, through a combination of hydrophobic inclusion and hydrogen-bonding interactions, several of which have been shown to possess enhanced biological activity, including interferon-inducing activity, relative to the parent compounds [16]. This “host–guest” complexation behaviour, well documented for glycyrrhizic acid’s organic guest complexes, extends in principle to complexation with metal ions, offering a route to metal–glycyrrhizate supramolecular complexes whose combined organic-carrier and metal-micronutrient character makes them attractive candidates for agricultural biostimulant applications, particularly in regions such as Karakalpakstan where soil salinity and micronutrient availability constrain crop productivity.

3. Materials and Methods

3.1. Plant Material

Five-year-old licorice root, both wild-growing and under cultivation, was collected from the central and southern districts of the Republic of Karakalpakstan (Nukus, Kegeyli, Beruniy, and Ellikqala districts). Root material was cleaned, air-dried, and disintegrated prior to extraction. A commercially available thick aqueous extract of licorice root, of the kind produced by the private firm “LAKRISA,” was used as the starting material for the acid-precipitation experiments described below.

3.2. Extraction of Technical Glycyrrhizic Acid

Technical glycyrrhizic acid (TGK) was precipitated from the thick licorice-root extract by acidification with dilute sulfuric acid. In a representative preparation, 500 g of thick extract was dissolved in water at a 1:15 ratio and treated, with stirring, with 1% sulfuric acid until the solution reached a weakly acidic pH (3.5–4.0) and precipitation of technical glycyrrhizic acid ceased. The initially resin-like precipitate was converted to an amorphous powder by repeated decantation washing with water, filtered, washed with water to neutrality, and dried first in air and then in a drying oven, giving a brown amorphous powder (175 g; 35% relative to the starting extract).

To identify the reaction conditions that maximize precipitation yield, the volume of concentrated sulfuric acid added to a fixed mass and concentration of extract (200 g extract, 10% concentration in solution) was systematically varied from 7 to 16 mL, and the resulting solution pH and TGK yield were recorded for each trial (Table 1).

3.3. Synthesis of the Ammonium Salts

The triammonium salt of glycyrrhizic acid was prepared by extracting 100 g of technical glycyrrhizic acid with 1 L of acetone at reflux for 3 hours in a three-necked, 2000 mL flask equipped with a mechanical stirrer and reflux condenser; after cooling, the mixture was filtered and the residue re-extracted twice more with 1 L of acetone. The combined acetone filtrates were treated with concentrated aqueous NH4OH until the extract reached pH 7.5–8.0, precipitating the yellow triammonium salt, which was collected on a Büchner funnel, washed with ethyl alcohol (3 × 30 mL), and dried first at room temperature and then at 100 °C (32 g; 32% yield; $[\alpha]D25 = +38 \pm 2°$, c = 0.02% in 50% C2H5OH).

The triammonium salt was converted to the monoammonium salt by boiling with glacial acetic acid, and the resulting monoammonium salt was recrystallized from 80% ethyl alcohol, giving the pure monoammonium salt in 88% yield relative to the triammonium salt. Two monoammonium salt samples of differing purity were used for comparative physicochemical characterization: a 97%-purity sample prepared in-house (designated GKMAD-2) and a 75%-purity commercial reference sample of “Gliciram,” produced by Chimkentbiofarm ICHB, Republic of Kazakhstan (designated GKMAD-1).

3.4. Physicochemical Characterization

Melting points were determined using a PTP TU 25-11-1144 apparatus. Optical rotation was measured with an SM-2 polarimeter (1 dm cell path length) in 50% ethyl alcohol containing 0.25% NH4OH. Refractive indices were determined with an IRF-22 refractometer. Potentiometric titration of the free carboxyl groups of the GKMAD-1 and GKMAD-2 monoammonium-salt samples was carried out on an EV-74 universal ionometer, at constant temperature with stirring, using 0.2% aqueous sample solutions titrated against standardized 0.1 M alkali; apparent pKa values were calculated from the titration curves using the Henderson–Hasselbalch equation. Infrared spectra were recorded on a Perkin-Elmer FT-IR System 2000 spectrometer using KBr pellets; ultraviolet spectra of compound solutions were recorded on a Perkin-Elmer Lambda-16 spectrometer (1 cm quartz cells); and proton magnetic resonance (PMR) spectra

were recorded at a working frequency of 100 MHz on a Varian XL-100 spectrometer, using 10% solutions of the samples in deuterated dimethyl sulfoxide (DMSO-d6) with tetramethylsilane (TMS) as internal standard.

3.5. Synthesis of the Copper Supramolecular Complex

The copper supramolecular complex of technical glycyrrhizic acid (designated CuproTGK) was synthesized from the purified glycyrrhizic acid derivative with the aim of obtaining a natural-product-based agricultural biostimulant. The structure of the resulting compound was confirmed by infrared spectroscopy, which indicated that the CuproTGK supramolecular complex forms on a "host–guest" structural basis, arising from mutual hydrophobic interaction between the glycyrrhizic acid framework and the coordinated copper species together with hydrogen bonding between them.

4. Results

Table 1 presents the effect of the concentrated sulfuric acid volume, and the resulting solution pH, on the yield of technical glycyrrhizic acid obtained from a fixed mass (200 g) and concentration (10%) of licorice root extract.

Table 1. Effect of the acidification medium on the yield of technical glycyrrhizic acid

Trial No.	Conc. H_2SO_4 added (mL)	Resulting pH	TGK yield (%)
1	7	4.00	17.0
2	8	3.87	17.5
3	9	3.73	17.8
4	10	3.50	18.8
5	11	3.32	19.5
6	12	3.20	20.7
7	13	2.91	21.8
8	14	2.62	19.5
9	15	2.40	17.5
10	16	2.10	15.0

As shown in Table 1, the yield of technical glycyrrhizic acid rises with increasing sulfuric acid volume up to a maximum of 21.8% at trial 7 (13 mL, pH 2.91), beyond which further acid addition (trials 8–10) results in a progressive decline in yield to as low as 15.0% at pH 2.10. The optimal precipitation window therefore corresponds to a solution pH of approximately 2.5–3.2, consistent with the general literature observation that dilute-acid, gradual precipitation favours a cleaner amorphous product and reduces co-precipitation of ballast material.

Under the representative preparative conditions described in Section 3.2, technical glycyrrhizic acid was obtained in 35–40% yield relative to the starting thick root extract (175 g from 500 g of extract; 35%), with a comparison of wild-growing and cultivated root sources confirming that cultivated licorice root yields substantially more extractable glycyrrhizic acid than wild-growing root collected from the same districts. Conversion of the technical acid to the triammonium salt via acetone extraction and ammonia treatment proceeded in 32% yield, and subsequent conversion of the triammonium to the monoammonium salt, via glacial acetic acid treatment and recrystallization from 80% ethanol, proceeded in 88% yield. Using the full sequence directly from crude root extract to pure crystalline glycyrrhizic acid, an overall yield of 8–10% was obtained, a figure that the analysis identifies as a significant determinant of the final product's cost. The purified crystalline acid had a melting point of 222 ± 2 °C and an optical rotation of $[\alpha]D25 = +60 \pm 2°$ (c = 0.05%, in ethyl alcohol), both in agreement with literature reference values for glycyrrhizic acid.

Table 2 presents the results of potentiometric titration of the free carboxyl groups in the two monoammonium salt samples, GKMAD-1 (75% purity, commercial "Gliciram" reference) and GKMAD-2 (97% purity, prepared in this study).

Table 2. Potentiometric titration of glycyrrhizic acid monoammonium salt samples of differing purity

Parameter	GKMAD-1 (75% purity)	GKMAD-2 (97% purity)
Free carboxyl groups (per molecule)	2.7	3.2
Apparent pKa	4.6	4.6

The potentiometric titration curves for both samples showed a clear inflection over the range 1.1–1.6 mL of consumed 0.1 M NaOH, confirming the presence of free carboxyl groups. The free carboxyl group content calculated

from these curves — 2.7 for GKMAD-1 and 3.2 for GKMAD-2, against a theoretical value of three free carboxyl groups per monoammonium salt molecule — indicates that the higher-purity, in-house-prepared sample (GKMAD-2) more closely approaches the theoretical stoichiometry than the 75%-purity commercial reference. The apparent pKa of 4.6 obtained for both samples is close to that of acetic acid (pKa = 4.76), consistent with the carboxylic acid character of the titrated groups.

Infrared spectroscopic analysis of the product obtained by reacting the purified glycyrrhizic acid derivative with a copper source confirmed formation of the CuproTGK supramolecular complex, with spectral changes consistent with a “host–guest” complexation mode arising from combined hydrophobic interaction and hydrogen bonding between the glycyrrhizic acid framework and the coordinated copper species, rather than from a simple physical mixture of the two components.

5. Discussion

The pH-dependence of technical glycyrrhizic acid precipitation observed in this study (Table 1) provides a practical basis for optimizing extraction yield under regional production conditions: operating at a controlled pH of approximately 2.9, rather than adding excess concentrated acid in a single step, increased yield by more than six percentage points relative to the least favourable condition tested (21.8% versus 15.0%) while avoiding the resinous, ballast-laden precipitate associated with over-acidification. Because the same acidification step also governs the physical form of the precipitate and, downstream, the efficiency of subsequent acetone extraction and ammonium-salt conversion, this optimization has consequences that extend beyond the immediate precipitation yield to the overall economics of the extraction sequence.

The finding that cultivated licorice root yields substantially more extractable glycyrrhizic acid than wild-growing root collected from the same districts is of direct practical relevance to regional agricultural and industrial policy: it supports the case, already reflected in national decrees promoting licorice cultivation and export, for directing raw-material sourcing toward cultivated plantations rather than relying solely on wild stands, both to secure a more concentrated and predictable source of glycyrrhizic acid and to relieve harvesting pressure on wild licorice populations, whose reserves in the lower Amu Darya region have previously been shown to be sensitive to anthropogenic disturbance.

The physicochemical comparison between the in-house 97%-purity monoammonium salt (GKMAD-2) and the 75%-purity commercial “Gliciram” reference (GKMAD-1) indicates that the extraction and purification sequence used in this study is capable of producing material that matches, and on the free-carboxyl-group metric slightly exceeds, an established regional pharmaceutical-grade benchmark. Because free carboxyl group content bears directly on the compound’s capacity for further derivatization — including, as demonstrated here, complexation with metal ions — this level of purity is a meaningful indicator of the material’s suitability for downstream supramolecular chemistry rather than a purely analytical curiosity.

The successful synthesis of the CuproTGK copper supramolecular complex, and its structural confirmation by infrared spectroscopy as a host–guest assembly stabilized by hydrophobic interaction and hydrogen bonding, extends the established precedent of glycyrrhizic acid’s complexation with organic guest molecules to a metal-ion guest. Because copper is both a plant micronutrient and, in supramolecular combination with an organic natural-product carrier, a candidate route to a biodegradable, low-toxicity agrochemical, this complex forms a natural bridge between the extraction chemistry reported here and the agronomic evaluation of CuproTGK as a seed and crop biostimulant, which is reported separately.

Several limitations of the present study should be noted. The reported yields and physicochemical constants derive from single representative preparative runs rather than replicate batches, so their variability has not been formally quantified; the wild-versus-cultivated yield comparison is reported qualitatively rather than as a matched, statistically analyzed dataset; and the infrared characterization of the CuproTGK complex, while sufficient to confirm host–guest complex formation, was not accompanied in this work by full peak assignment or by complementary structural techniques such as PMR or elemental analysis of the isolated complex itself. Addressing these points in future work would strengthen the quantitative basis for scaling the extraction and complexation methodology to larger production volumes.

6. Conclusion

This study establishes a reproducible extraction and derivatization route from regionally grown Karakalpakstan licorice root to purified glycyrrhizic acid and its copper supramolecular complex. Acidification of the thick root extract with dilute sulfuric acid at a controlled pH of approximately 2.9 maximized technical glycyrrhizic acid yield (21.8%),

and the subsequent ammonium-salt conversion sequence gave pure crystalline glycyrrhizic acid, with physicochemical constants matching literature values, in an overall yield of 8–10% from crude extract. Cultivated licorice root was found to be a substantially more productive source of extractable glycyrrhizic acid than wild-growing root, and the purified monoammonium salt prepared in this study compared favourably, in free carboxyl group content, with a commercial regional reference preparation. The resulting material was successfully used to synthesize a copper supramolecular complex, CuproTGK, whose host–guest structure was confirmed by infrared spectroscopy. Together, these findings support the technical and economic feasibility of local, value-added processing of Karakalpakstan licorice root into pharmaceutical- and agrochemical-grade glycyrrhizic acid derivatives, and they establish the chemical basis for the agronomic biostimulant evaluation of CuproTGK reported in the companion study.

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The Effectiveness of Flipped Classroom Technology in Teaching the Topic of Surface Phenomena in Chemistry Education

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Abstract

Surface phenomena - the physicochemical processes that occur at the boundary between two phases - underlie a wide range of everyday and industrial contexts, from the cleaning action of soap to the function of medical adsorbents and industrial gas purification, yet the topic is frequently perceived by students as abstract and difficult to visualize. This study investigated whether flipped classroom technology could improve learning outcomes for this topic relative to traditional, lecture-based instruction. Using a quasi-experimental comparative design, thirty undergraduate chemistry students were divided into two groups of fifteen: a traditionally taught group and a flipped classroom group. Students in the flipped classroom group studied core theoretical material - surface tension, surfactants, and adsorption - at home through instructor-provided video lectures before attending a class session built around Learning Apps interactive matching exercises, real-world demonstrations of surface phenomena drawn from nature and daily life, and a collaborative mind-mapping exercise conducted on the Miro online whiteboard in which students generated and developed an applied design concept. Learning outcomes, scored on a ten-point scale, were evaluated using two standard indicators: academic performance and quality of knowledge. The flipped classroom group achieved an academic performance rate of 100% and a knowledge quality rate of 73.3%, compared with 73.3% and 26.7%, respectively, in the traditionally taught group. Every student in the flipped classroom group achieved a passing score, and none scored in the lowest passing band, in contrast to the traditional group. These results, consistent in direction with those obtained for a parallel colloid-chemistry topic within the same broader study, suggest that flipped classroom instruction is particularly effective for topics such as surface phenomena that lend themselves to abundant real-world illustration and applied, creative synthesis. Pedagogical implications and directions for future research are discussed.

Keywords: flipped classroom, innovative educational technology, surface phenomena, adsorption, colloid chemistry, chemistry education, academic performance

1. Introduction

Surface phenomena - the physicochemical processes that take place specifically at the interface between two phases - constitute one of the most pervasive yet least visually intuitive domains of physical and colloid chemistry. Surface tension explains why a water strider can stand on the surface of a pond and why mercury spilled from a broken thermometer gathers into rounded droplets on a tabletop; adsorption explains why activated carbon and silica gel can purify water and air, and why a common medicinal preparation based on colloidal silica (marketed as Polysorb) can absorb toxins in the digestive tract; and capillarity explains how water and dissolved minerals rise from the soil through the narrow channels of plant roots even in dry conditions. Despite this rich and immediately relatable set of real-world manifestations, students frequently encounter the formal vocabulary of surface phenomena - terms such as adsorbent, adsorbate, adsorption isotherm, adhesion, and cohesion - as an abstract and disconnected list of definitions to be memorized rather than as a coherent framework for understanding phenomena they already observe daily. This gap between the abstractness of the formal terminology and the concreteness of the underlying phenomena makes surface phenomena a particularly instructive test case for pedagogical approaches, such as the flipped classroom, that emphasize active engagement and real-world grounding over passive transmission of definitions.

As in the parallel investigation of the “Disperse Systems” topic conducted within the same broader thesis project, the flipped classroom model examined here was first developed in 2007 by Jonathan Bergmann and Aaron Sams as a solution for students who frequently missed class, and has since become one of the most widely discussed innovative pedagogical technologies of the twenty-first century [3]. The model relocates the initial delivery of theoretical content to an asynchronous, self-paced home stage, typically through recorded video lectures, so that classroom time can instead

be devoted to the application, discussion, and consolidation of that material under the direct guidance of the instructor. Where the disperse-systems study emphasized competitive, hands-on laboratory experimentation as the principal in-class activity, the design of the present study capitalized on the abundance of everyday, easily observable examples of surface phenomena by building the in-class stage around real-world demonstration, interactive digital matching exercises, and a creative, applied mind-mapping task, testing whether the flipped model's benefits extend to a topic whose pedagogical strength lies less in laboratory manipulation than in connecting abstract theory to lived experience.

The aim of this study was therefore to evaluate the effectiveness of flipped classroom technology, relative to traditional lecture-based instruction, in teaching the topic of "Surface Phenomena," as measured by academic performance and quality of knowledge, and to compare the pattern of results with that obtained for the disperse-systems topic in order to assess the consistency of the flipped classroom's effect across two distinct areas of the colloid chemistry curriculum.

2. Literature Review

2.1. Innovative Pedagogy and the Flipped Classroom

The concept of innovation entered educational scholarship only in the mid-twentieth century, considerably later than in economics, where the term originated in the work of Schumpeter in the 1930s [5], and post-Soviet pedagogy did not begin to engage systematically with innovation until the late 1970s. Contemporary scholarship emphasizes that innovative and traditional teaching methods should be viewed as complementary rather than competing, with the instructor's task being to identify an optimal balance that preserves the strengths of direct instruction while incorporating the flexibility and active engagement that innovative methods, including the flipped classroom, can provide [2]. The flipped classroom itself inverts the conventional order of instruction, moving the initial transmission of theoretical content to an asynchronous home stage, typically via recorded video lectures, so that class time can be reserved for application, practice, and discussion under the instructor's direct supervision [3].

In the Kazakhstani higher education context specifically, several studies have documented both growing interest in, and continuing barriers to, the adoption of digital and blended learning technologies. Yerzhanova and Nurgaliyeva [12] examined technology integration in Kazakhstani classrooms, while Ospanova and Mussina [6] documented broader trends in the use of information and communication technologies in Kazakhstani higher education, and Zhumabayeva and Zhaparova [13] catalogued practical implementation challenges for e-learning in the country's universities. Together, this body of work underscores the need for concrete, topic-level evidence of the kind this study seeks to provide.

2.2. Theoretical Background: Surface Tension and Surfactants

Within a liquid, any given molecule is surrounded on all sides by neighboring molecules of the same substance, and the attractive forces it experiences are, on average, balanced in every direction. A molecule located at the liquid's surface, however, has neighboring molecules only below and to the sides, and none above; the resulting imbalance of attractive forces draws surface molecules inward, toward the bulk liquid phase, causing the surface to contract to the minimum area consistent with the liquid's volume and giving rise to the phenomenon of surface tension, experienced physically as an elastic, film-like layer at the liquid's surface [7].

Surface-active substances, more commonly known as surfactants, are chemical compounds that concentrate at the interface between two phases (for example, between a liquid and a solid, between two immiscible liquids, or between a liquid and a gas) and thereby reduce the surface tension at that interface. Surfactants are classified according to the nature of the ionic species they form in solution: anionic surfactants (such as sodium laureth sulfate) dissociate into negatively charged ions; cationic surfactants (such as benzalkonium chloride) dissociate into positively charged ions; amphoteric surfactants (such as betaines) display cationic character in acidic solution and anionic character in alkaline solution; and non-ionic surfactants (such as fatty alcohols) do not ionize at all [8]. All surfactant molecules share a characteristic amphiphilic structure, comprising a hydrophobic segment and a hydrophilic segment, which together allow the molecule to interact simultaneously with both water-soluble and oil-soluble residues - the physicochemical basis of soap's cleaning action.

At low concentrations, surfactant molecules adsorb at an available interface, progressively lowering the surface tension there; however, above a substance-specific threshold known as the critical micelle concentration, additional surfactant molecules can no longer further reduce surface tension and instead self-assemble in the bulk solution into structures called micelles - spherical or lamellar aggregates in which the hydrophobic tails of dozens or hundreds of surfactant molecules orient inward, away from the surrounding water, while the hydrophilic heads orient outward,

toward it [10]. This micellar structure allows non-polar contaminants to be solubilized within the hydrophobic interior of the micelle - the molecular mechanism underlying detergency.

2.3. Theoretical Background: Adsorption, Wetting, and Capillarity

Adsorption is the spontaneous process by which a solid or liquid surface accumulates a gas, vapor, or dissolved substance, manifesting as an increase in the concentration of that substance specifically at the interface between the two phases, as opposed to absorption, in which the substance is taken up throughout the volume of the absorbing material [4]. The substance that performs the adsorbing is termed the adsorbent, the substance that becomes adsorbed onto the surface is termed the adsorbate, and the substance available in the surrounding volume for potential adsorption is termed the adsorptive. Adsorption is further distinguished into physical adsorption (physisorption), which arises from comparatively weak van der Waals forces and is generally reversible, and chemisorption, which involves the formation of a genuine chemical bond between adsorbate and surface and is typically far less readily reversed [11].

Common adsorbents - including activated carbon, zeolites, and silica gel - share a highly porous, microstructured architecture that maximizes surface area per unit mass, and are widely employed in petrochemical processing, industrial air purification, gas drying, and water treatment, as well as, in the case of finely divided colloidal silica, in medicinal preparations designed to bind toxins, allergens, and pathogenic bacteria within the digestive tract [9]. The reverse process, in which a previously adsorbed substance is released back from the surface into solution, is termed desorption, and the relationship between the equilibrium quantity of adsorbate held on a surface and its concentration in the surrounding phase, at constant temperature, is described by an adsorption isotherm, most classically the Langmuir isotherm [8].

Wetting and capillarity represent a further category of surface phenomena arising at the boundary between a liquid and a solid. Wetting describes the interaction between a liquid and a solid surface, and its extent depends on the relative strengths of cohesive forces (holding molecules of the liquid together) and adhesive forces (attracting liquid molecules to the solid surface). Capillarity - the rise or fall of a liquid within a narrow tube or channel relative to the surrounding liquid level - is itself a consequence of the balance between these cohesive and adhesive forces acting at a curved liquid surface, and it accounts for the passive upward transport of water and dissolved minerals through the fine channels of soil and, subsequently, through plant root systems [7, 11].

3. Materials and Methods

3.1. Research Design and Participants

This study employed the same quasi-experimental, comparative-group design and the same participant pool as the parallel investigation of the “Disperse Systems” topic within the broader thesis project: thirty undergraduate students from group B053-5306-23-01 of the educational program 6B05306 “Chemistry of Organic Substances and Polymers” at L.N. Gumilyov Eurasian National University, divided into a fifteen-student traditional group and a fifteen-student flipped classroom group, matched for comparable prior academic performance. Conducting both topic investigations with the same two groups allowed the effect of instructional format to be examined across two distinct chemistry topics while holding the student population, group composition, and institutional context constant.

3.2. Procedure

Traditional group. Instruction in the traditional group opened with a brief organizational stage (1-2 minutes) and a short assessment of students’ prior preparation and of the conceptual link between physics and chemistry (5-7 minutes), introduced through a problem-based question inviting students to explain why a drop of water spreads across a clean glass surface but does not spread on a paraffin-coated surface. Presentation of new material (20-25 minutes) then covered, in sequence, surface tension; surface-active substances and their classification, including the critical micelle concentration; and adsorption, delivered through direct oral explanation and lecture notes emphasizing key definitions. The lesson concluded with an initial consolidation exercise (10 minutes) in which students applied the material just presented to explain the cleaning action of soap, followed by a review of the lesson and assignment of homework based on the provided lecture notes.

Flipped classroom group. During the asynchronous home stage (7-10 minutes), students in the flipped classroom group prepared independently using instructor-provided lecture notes and three recorded video lectures covering surface tension, surfactants, and adsorption, and completed a preparatory task requiring them to identify everyday examples of adsorption - such as household water filters and the silica gel packets found in footwear packaging - and to name the substance functioning as the adsorbent in each case.

The synchronous in-class stage centered on active learning. A blitz oral-and-digital quiz was conducted using interactive exercises built on the Learning Apps platform, including a matching-table exercise requiring students to pair images with the correct designation of "surface phenomenon" or "not a surface phenomenon," and several "find the pair" games requiring students to match examples with categories such as the four classes of surfactant (anionic, cationic, amphoteric, and non-ionic) and adsorption-related terminology (adsorbent, adsorbate, physisorption, chemisorption, desorption, and the adsorption isotherm). To ground the topic's terminology in direct experience, the instructor incorporated a series of real-world illustrations of surface phenomena drawn from nature and daily life, including the water strider's ability to stand on the surface of still water, the formation of rounded mercury droplets from a broken glass thermometer, the beading of dew on a leaf surface, and the capillary rise of moisture through soil to a plant's root system.

The lesson concluded with a collaborative synthesis activity conducted on the Miro online whiteboard, structured as a three-stage mind-mapping process: an initial brainstorming stage in which students generated candidate product ideas; a selection stage in which each student identified their preferred idea from those generated; and a realization stage in which students articulated how their chosen idea could be developed into a socially useful product. In one illustrative example produced during this activity, a student proposed a self-cleaning solar panel design that would exploit surface tension together with the lotus effect - the naturally occurring combination of microscale surface roughness and low surface energy that allows certain plant leaves to shed water and accumulated dirt - to keep the panel's surface clean without manual intervention.

3.3. Assessment

Student learning outcomes for the "Surface Phenomena" topic were assessed using a multiple-choice knowledge test scored on the same ten-point scale employed for the "Disperse Systems" module, preserving methodological consistency across the two topic-level investigations conducted within the broader study.

3.4. Data Analysis

As in the companion investigation, two summary indicators were computed from each group's distribution of ten-point scores: academic performance, the percentage of students scoring above the minimum passing threshold (6, 8, or 10 points), and quality of knowledge, the percentage of students achieving a high score (8 or 10 points).

4. Results

Table 3 lists the key terms and definitions covered in the "Surface Phenomena" lesson, which were presented to students in accessible language alongside the demonstrations and digital exercises described above.

Table 3. Key terms and definitions used in the "Surface Phenomena" topic

Term	Definition
Adsorption	Spontaneous accumulation of a substance at the interface between two phases
Adsorbent	The substance on whose surface adsorption occurs
Adsorbate	The substance adsorbed from a gas or liquid
Physical adsorption	Adsorption occurring through van der Waals forces
Chemisorption	A chemical reaction occurring between the adsorbate and the surface
Surface phenomenon	Physicochemical processes occurring at the interface between phases
Adhesion	The joining of the surfaces of two different bodies
Cohesion	The bonding of molecules within a single substance
Wetting	The interaction between a liquid and a solid surface
Adsorption isotherm	The relationship between the quantity of adsorbate and its concentration, at constant temperature

Table 4 presents the distribution of test scores obtained by the traditional and flipped classroom groups.

Table 4. Test score distribution: traditional vs. flipped classroom teaching of "Surface Phenomena"

Score (points)	Traditional Group (n = 15)	Flipped Classroom Group (n = 15)
10	0	3
8	4	8

Score (points)	Traditional Group (n = 15)	Flipped Classroom Group (n = 15)
6	7	4
4	4	0
2	0	0
0	0	0

As shown in Table 4, no student in either group scored zero or two points, and no student in the flipped classroom group scored below six points, whereas four students in the traditional group scored only four points. At the upper end of the scale, three students in the flipped classroom group achieved the maximum score of ten points, compared with none in the traditional group, while eight students in the flipped classroom group scored eight points, compared with four in the traditional group.

Applying the academic performance and quality-of-knowledge indicators, the flipped classroom group achieved a performance rate of 100%, meaning that every student in the group achieved a passing score, and a quality-of-knowledge rate of 73.3%. The traditional group achieved a performance rate of 73.3% and a quality-of-knowledge rate of 26.7%. The flipped classroom group's performance rate thus exceeded that of the traditional group by 26.7 percentage points, and its quality-of-knowledge rate exceeded that of the traditional group by 46.6 percentage points.

5. Discussion

The results provide clear evidence of the flipped classroom model's effectiveness in teaching the "Surface Phenomena" topic, with every measured indicator favoring the flipped classroom group over the traditionally taught group. Notably, the magnitude of the advantage observed here exceeds that observed for the parallel "Disperse Systems" topic conducted within the same broader study, in which the flipped classroom group's performance and quality-of-knowledge rates exceeded the traditional group's by 13.3 and 33.4 percentage points, respectively, compared with 26.7 and 46.6 percentage points for surface phenomena. The perfect 100% passing rate achieved by the flipped classroom group, with not a single student scoring below the passing threshold, is a particularly striking result given that four students - more than a quarter of the traditionally taught group - failed to reach that same threshold.

Several features of the surface phenomena lesson design may help explain why the flipped classroom's advantage was even more pronounced for this topic than for disperse systems. First, surface phenomena lend themselves unusually well to illustration through commonplace, easily relatable examples: the water strider resting on a pond's surface, mercury droplets on a tabletop, dew on a leaf, and the capillary movement of water through soil are phenomena that most students have already observed in daily life, even if they had not previously connected them to a shared underlying physicochemical principle. Anchoring the abstract vocabulary of adsorbents, adsorbates, and adsorption isotherms to this kind of lived experience - an approach made possible by the classroom time freed up under the flipped model - appears to have been an effective route to durable understanding, consistent with the broader emphasis in the innovative-pedagogy literature on building genuine functional literacy rather than the rote memorization of definitions [1]. Second, the collaborative Miro mind-mapping exercise, culminating in applied product concepts such as the lotus-effect self-cleaning solar panel proposed by one student, required learners to synthesize and transfer their newly acquired knowledge to a novel design problem - a demanding cognitive task that is only feasible once foundational definitions have already been secured, in this case through the preceding asynchronous home stage - and that plausibly contributed to moving a large share of students into the highest-scoring band on the subsequent assessment.

These findings are consistent with, and extend, the results obtained for the disperse-systems topic within the same broader thesis project, and together the two topic-level investigations offer convergent evidence that the flipped classroom's advantage over traditional instruction, in this setting, is not confined to a single content area but generalizes across at least two substantively distinct areas of the colloid chemistry curriculum - one weighted more heavily toward hands-on laboratory manipulation and one weighted more heavily toward real-world illustration and applied synthesis. This pattern also aligns with the broader international literature on flipped learning [3] and with the documented momentum behind digital and blended learning approaches in Kazakhstani higher education [6, 12].

The limitations noted in the companion study apply equally here: the sample was limited to thirty students from a single institution and student cohort, the intervention spanned a single lesson on a single topic, and the use of intact, non-randomly assigned groups means that pre-existing group differences and a possible novelty effect associated with the introduction of new digital tools cannot be fully excluded as alternative explanations for the observed differences. Future research employing larger, randomly assigned samples across multiple institutions, and tracking the retention of

learning gains over a longer time horizon, would help to establish the robustness and durability of the effects reported here.

6. Conclusion

This study evaluated the effectiveness of flipped classroom technology, relative to traditional lecture-based instruction, in teaching the topic of "Surface Phenomena" to undergraduate chemistry students. Students taught using the flipped classroom model - which combined asynchronous video-based instruction with in-class real-world demonstrations, interactive Learning Apps exercises, and a collaborative Miro-based mind-mapping and applied design task - achieved a 100% academic performance rate and a 73.3% quality-of-knowledge rate, compared with 73.3% and 26.7%, respectively, among students taught through the traditional lecture format. Considered alongside the parallel results obtained for the "Disperse Systems" topic within the same broader study, these findings suggest that the benefits of flipped classroom instruction are consistent - and may be especially pronounced - for chemistry topics such as surface phenomena that offer rich opportunities to connect abstract terminology to directly observable, everyday phenomena. Chemistry instructors are encouraged to consider flipped classroom designs that pair asynchronous foundational instruction with in-class activities emphasizing real-world grounding, interactive digital practice, and applied, creative synthesis, particularly for topics of comparable conceptual character.

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Zamonaviy kutubxonalarda axborot-resurslarini saqlash va ulardan samarali foydalanish

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Annotatsiya

Ushbu maqolada zamonaviy axborot-kutubxona muassasalarida axborot-resurslarini shakllantirish, hisobga olish, kataloglashtirish, saqlash, raqamlashtirish va foydalanuvchilarga samarali yetkazib berish masalalari tahlil qilinadi. Tadqiqotda kutubxona fondi bilan ishlashning nazariy va amaliy jihatlari o‘zbek tilidagi kutubxonashunoslik darsliklari va o‘quv qo‘llanmalari asosida yoritiladi. Axborot resurslarining jismoniy xavfsizligi bilan bir qatorda elektron resurslarning saqlanishi, metadata sifati, elektron kataloglardan foydalanish, kitobxonlarga xizmat ko‘rsatish va kutubxona xodimlarining kasbiy kompetensiyalarini rivojlantirish masalalariga alohida e’tibor qaratiladi. Maqolada axborot-resurs fondini boshqarishni takomillashtirish bo‘yicha amaliy tavsiyalar ishlab chiqilgan. Tadqiqot natijalari kutubxona fondlarini zamonaviy talablar asosida boshqarish, resurslardan foydalanish imkoniyatlarini kengaytirish va xizmatlar sifatini oshirishga yo‘naltirilgan.

Kalit so‘zlar: axborot-kutubxona, kutubxona fondi, axborot-resurslari, fondlarni saqlash, kataloglashtirish, elektron katalog, raqamlashtirish, kitobxonlarga xizmat ko‘rsatish, kutubxonashunoslik, axborot texnologiyalari.

Kirish

Raqamli texnologiyalar jadal rivojlanayotgan hozirgi davrda kutubxonalarning vazifasi faqat bosma nashrlarni saqlash bilan cheklanib qolmayapti. Zamonaviy axborot-kutubxona muassasasi bosma, elektron va raqamli resurslarni bir tizimda boshqaradigan, ularni izlash va foydalanish imkoniyatlarini ta’minlaydigan axborot-madaniy markaz sifatida faoliyat yuritmoqda. Shu sababli kutubxona fondlarini to‘ldirish, saqlash va ulardan samarali foydalanishni tashkil etish kutubxona faoliyatining muhim yo‘nalishlaridan biridir.

O‘zbek kutubxonashunoslik adabiyotlarida axborot-kutubxona muassasalarining asosiy jarayonlari, fondni shakllantirish, hujjatlarga ishlov berish, katalog va kartotekalarni tashkil etish hamda kitobxonlarga xizmat ko‘rsatish masalalari izchil yoritilgan. Xususan, B.I. Ganiyevaning “Kutubxonashunoslik” darsligida sohaning rivojlanish tendensiyalari, axborot-kutubxona muassasalari tarmog‘i, ularning tuzilishi va boshqarish tamoyillari bayon qilingan [1]. B.I. Ganiyevaning “Axborot-kutubxona katalogi va fondi” o‘quv qo‘llanmasida esa fondni shakllantirish, hujjatlarga ishlov berish, sistemalashtirish va kataloglar tizimini tuzish masalalari batafsil yoritilgan [2].

Mazkur maqolada shu ilmiy-uslubiy qarashlar zamonaviy kutubxona amaliyoti bilan bog‘langan holda ko‘rib chiqiladi. Maqolaning asosiy e’tibori axborot-resurslarini saqlash va ulardan samarali foydalanish o‘rtasidagi uzviy bog‘liqlikni ochib berishga qaratilgan.

Tadqiqotning maqsadi va vazifalari

Tadqiqotning maqsadi zamonaviy kutubxonalarda axborot-resurslarini saqlash va ulardan foydalanish samaradorligini oshirishning tashkiliy, bibliografik, texnologik hamda xizmat ko‘rsatish jihatlarini ilmiy-uslubiy asosda yoritishdan iborat.

Ushbu maqsadga erishish uchun quyidagi vazifalar belgilandi: kutubxona axborot-resurslarining tarkibi va xususiyatlarini aniqlash; fondni shakllantirish va hisobga olish jarayonlarini tahlil qilish; hujjatlarga bibliografik va texnik ishlov berishning ahamiyatini ko‘rsatish; bosma resurslarni saqlash sharoitlarini yoritish; elektron va raqamli resurslarni boshqarish masalalarini ko‘rib chiqish; elektron katalog va axborot qidiruv imkoniyatlaridan foydalanish yo‘llarini tavsiflash; foydalanuvchilarga xizmat ko‘rsatish samaradorligini oshirish bo‘yicha amaliy tavsiyalar ishlab chiqish.

Tadqiqot metodologiyasi

Tadqiqot nazariy-tahliliy xarakterga ega. Unda kutubxonashunoslikka oid o‘zbek tilidagi darslik, o‘quv qo‘llanma va ilmiy-uslubiy manbalarni o‘rganish, taqqoslash, umumlashtirish va tizimlashtirish usullaridan foydalanildi. Asosiy manbalar sifatida B.I. Ganiyevaning “Kutubxonashunoslik” darsligi [1], “Axborot-kutubxona katalogi va fondi” o‘quv qo‘llanmasi [2], Z.Sh. Berdiyevaning “Kutubxonashunoslik” o‘quv qo‘llanmasi [3], shuningdek O‘zbekiston davlat san’at va madaniyat instituti Kutubxona-axborot faoliyati kafedrasi tomonidan ko‘rsatilgan sohaviy adabiyotlar ro‘yxatidan foydalanildi [4].

Tadqiqot empirik statistik kuzatuvga emas, mavjud ilmiy-uslubiy adabiyotlar va kutubxona amaliyotining umumlashtirilgan tahliliga asoslangan. Shu bois maqolada aniq bir muassasaning statistik ko‘rsatkichlari umumiy natija sifatida talqin qilinmaydi.

1. Axborot-resurslarini shakllantirish va fonddan foydalanish

Kutubxona fondi muassasaning axborot salohiyatini belgilovchi asosiy tarkibiy qismdir. Fondning mazmuni foydalanuvchilarning ehtiyojlari, muassasaning vazifalari, hududning ijtimoiy-madaniy xususiyatlari va ta’limiy jarayonlar bilan uzviy bog‘liq bo‘lishi kerak. Fondni shakllantirishda adabiyotlarni mavzu, mazmun, til, nashr turi va foydalanuvchilarning ehtiyojlariga ko‘ra tanlash muhimdir.

B.I. Ganiyevaning “Axborot-kutubxona katalogi va fondi” asarida axborot-kutubxona fondining belgi va xususiyatlari, fondni shakllantirish prinsiplari va jarayonlari hamda hujjatlarga ishlov berish masalalari yoritilgan [2]. Bu yondashuv fondni tasodifiy jamlanma emas, balki maqsadli shakllantiriladigan va muntazam yangilanib boradigan axborot tizimi sifatida qarash imkonini beradi.

Fond samaradorligi faqat kitoblar soni bilan emas, balki ularning mazmuniy dolzarbligi, saqlanish holati, bibliografik tavsifining sifati va foydalanuvchiga qanchalik tez yetib borishi bilan ham belgilanadi. Shu sababli yangi adabiyotlarni qabul qilishdan boshlab ularni hisobga olish, inventar raqami berish, kataloglashtirish, sistemalashtirish, javonlarga joylashtirish va foydalanishga chiqarishgacha bo‘lgan jarayonlar yagona tizim sifatida tashkil etilishi lozim.

2. Axborot-resurslarini hisobga olish va hujjatlarga ishlov berish

Kutubxona fondini samarali boshqarishning muhim sharti resurslarni to‘g‘ri hisobga olish va bibliografik jihatdan tartibga solishdir. Har bir yangi kelib tushgan nashr tegishli tartibda qabul qilinib, hisob hujjatlarida qayd etilishi, unga zarur inventar va bibliografik ma’lumotlar biriktirilishi kerak. Hujjatlarga ishlov berish jarayoni resursni foydalanuvchiga tez va aniq topib berish uchun zarur bibliografik tartibni yaratadi.

Ganiyevaning o‘quv qo‘llanmasida katalog turlari, tasvir prinsiplari, hujjatlarga ishlov berish, sistemalashtirish hamda kutubxona-bibliografik klassifikatsiyalaridan foydalanish masalalari ko‘rsatilgan [2]. Demak, kataloglashtirish va sistemalashtirish faqat texnik ish emas, balki fondning axborot qiymatini foydalanuvchi uchun ochib beruvchi muhim jarayondir.

Amaliyotda bosma katalog bilan bir qatorda elektron katalogdan foydalanish resurslarni qidirish tezligini oshiradi. Elektron katalogda muallif, sarlavha, mavzu, kalit so‘z, nashr yili va boshqa bibliografik belgilar bo‘yicha qidirish imkoniyati foydalanuvchining mustaqil axborot izlash ko‘nikmasini rivojlantiradi.

3. Bosma axborot-resurslarini saqlash

Bosma fondning uzoq muddat saqlanishi uchun xonadagi sanitariya-gigiyena holati, harorat va namlikning me’yoriy barqarorligi, quyosh nurlarining bevosita ta’sirini kamaytirish, changdan tozalash va zararkunandalarning oldini olish kabi omillar hisobga olinadi. Kitoblarni javonlarga haddan tashqari zich joylashtirmaslik, og‘ir nashrlarni mos tartibda taxlash va shikastlangan hujjatlarni o‘z vaqtida ta’mirlash ham fondning saqlanishiga xizmat qiladi.

Fondlarni saqlash jarayonida hujjatlarning jismoniy holatini muntazam ko‘zdan kechirish muhim. Yirtilgan, namlangan yoki muqovasi shikastlangan nashrlarni aniqlash, ularni alohida ajratish va imkon qadar restavratsiya yoki ta’mirlash ishlarini tashkil etish zarur. Ayniqsa noyob, qimmatli va kamyob nashrlar bilan ishlashda ehtiyotkorlik talablari kuchaytirilishi kerak.

Kutubxona fondini saqlash bilan fondni rivojlantirish o‘rtasida muvozanat bo‘lishi lozim. Eskirgan yoki foydalanishga yaroqsiz resurslarni belgilangan tartibda hisobdan chiqarish, mazmunan dolzarb nashrlar bilan fondni to‘ldirish va foydalanuvchi talabidan kelib chiqib fond tarkibini yangilash uning samaradorligini oshiradi.

4. Elektron va raqamli axborot-resurslarini saqlash

Zamonaviy kutubxona fondining muhim qismi elektron resurslardan iborat. Elektron kitoblar, raqamli hujjatlar, ma'lumotlar bazalari va boshqa raqamli obyektlar an'anaviy kitoblardan farqli ravishda texnik infratuzilmaga bog'liq. Shuning uchun ularni saqlashda fayl formatlari, zaxira nusxalari, saqlash qurilmalari, kirish huquqlari va ma'lumotlar xavfsizligi kabi masalalar hisobga olinadi.

Raqamlashtirishning maqsadi faqat qog'oz hujjatni elektron faylga aylantirishdan iborat emas. Raqamlashtirilgan resursning nomi, muallifi, yaratilgan sanasi, mavzusi, fayl formati va boshqa metadata ma'lumotlarini to'g'ri yuritish ham muhim. Metadata qanchalik tartibli bo'lsa, raqamli resursni izlash va undan foydalanish shunchalik qulay bo'ladi.

Raqamli resurslarning yo'qolish xavfini kamaytirish uchun muhim fayllarning zaxira nusxalarini yaratish, ularni turli saqlash muhitlarida saqlash va muntazam tekshirish maqsadga muvofiq. Bunda axborot xavfsizligi, foydalanuvchilarning huquqlari va mualliflik huquqiga oid talablar ham hisobga olinishi kerak.

5. Elektron katalog va foydalanuvchiga axborot yetkazish

Elektron katalog kutubxona fondining foydalanuvchiga ko'rinadigan axborot qismidir. Foydalanuvchi kerakli adabiyotni kutubxona binosiga kelishdan oldin ham qidirishi, bibliografik ma'lumotlarni ko'rishi va mavjud resurs haqida dastlabki tasavvurga ega bo'lishi mumkin. Shu jihatdan elektron katalog kutubxona xizmatining tezkorligi va ochiqligini oshiruvchi vosita hisoblanadi.

Elektron katalogni samarali yuritish uchun bibliografik yozuvlarning yagona tamoyil asosida tuzilishi, nomlar va mavzularning izchil berilishi, takroriy yozuvlarning oldini olish va katalog ma'lumotlarini muntazam yangilab borish zarur. Ganiyevaning asarida kataloglar tizimi, tasvir prinsiplari va sistemalashtirish masalalarining yoritilgani ushbu jarayonning nazariy asosini tashkil etadi [2].

Foydalanuvchiga axborot yetkazish jarayonida an'anaviy bibliografik xizmatlar bilan bir qatorda elektron xizmatlar ham rivojlantirilishi kerak. Masofadan ma'lumot berish, elektron bibliografik ko'rsatkichlar, virtual ko'rgazmalar va raqamli tavsiya materiallari kitobxon bilan aloqani kengaytiradi.

6. Kitobxonlarga xizmat ko'rsatish samaradorligi

Kutubxona fondining haqiqiy qiymati undan foydalanish darajasi bilan ham belgilanadi. Shu sababli resurslarni saqlash bilan bir qatorda ularni kitobxonlarga faol targ'ib qilish, tematik ko'rgazmalar tashkil etish, yangi adabiyotlar taqdimotini o'tkazish va individual bibliografik xizmat ko'rsatish muhimdir.

Z.Sh. Berdiyevaning "Kutubxonashunoslik" o'quv qo'llanmasida kitobxonlarning o'qish madaniyatini rivojlantirish, adabiyotlarni targ'ib etish, ommaviy ish usullari, axborot-kutubxona xizmatlarini tashkil etish va hisobot-hisob jarayonlari yoritilgan [3]. Ushbu qarashlar zamonaviy sharoitda ham o'z ahamiyatini saqlab, an'anaviy xizmatlarni raqamli imkoniyatlar bilan uyg'unlashtirish zarurligini ko'rsatadi.

Kitobxonlarning ehtiyojini o'rganish uchun so'rovnomalar, takliflar qutisi, elektron murojaatlar, foydalanish statistikasi va kitob berish ko'rsatkichlaridan foydalanish mumkin. Olingan ma'lumotlar keyingi fondni to'ldirish jarayonida amaliy mezon sifatida xizmat qiladi.

7. Kutubxona xodimlarining kasbiy kompetensiyasi

Axborot-resurslarini samarali boshqarish ko'p jihatdan kutubxona xodimining kasbiy bilim va ko'nikmalariga bog'liq. Zamonaviy kutubxonachi bibliografik jarayonlarni bilish bilan birga elektron kataloglar, raqamli resurslar, axborot qidiruv tizimlari va foydalanuvchilarga masofaviy xizmat ko'rsatish vositalaridan ham foydalana olishi zarur.

B.I. Ganiyevaning "Kutubxonashunoslik" darsligida kutubxonachilik kasbining asosiy talablari va axborot-kutubxona muassasalarini tashkil etish hamda boshqarish tamoyillari ko'rib chiqilgan [1]. Bu esa xodimlarning malakasini muntazam oshirish, yangi texnologiyalarni o'zlashtirish va xizmat ko'rsatish madaniyatini rivojlantirish zarurligini asoslaydi.

Kutubxona xodimlari uchun qisqa muddatli amaliy seminarlar, ichki tajriba almashinuvi, elektron katalog bilan ishlash bo'yicha treninglar va raqamli savodxonlik mashg'ulotlarini yo'lga qo'yish mumkin. Bunday faoliyat fond bilan ishlashdagi xatolarni kamaytirish va foydalanuvchilarga xizmat ko'rsatish sifatini oshirishga yordam beradi.

8. Muhokama

Tahlil shuni ko'rsatadiki, zamonaviy kutubxonaning samaradorligi alohida bir jarayon bilan emas, balki fondni to'ldirish, hisobga olish, hujjatlarga ishlov berish, saqlash, kataloglashtirish va foydalanuvchiga yetkazishning yagona

tizim sifatida ishlashi bilan belgilanadi. O‘zbek kutubxonashunoslik adabiyotlarida mazkur jarayonlarning nazariy asoslari yetarlicha yoritilgan [1–4].

Shu bilan birga, raqamli muhitning kengayishi kutubxona amaliyotiga yangi talablarni olib kirmoqda. Elektron katalog, raqamli fond, metadata, ma’lumotlar xavfsizligi va masofaviy xizmatlar an’anaviy kutubxonachilik jarayonlari bilan uyg‘unlashmoqda. Natijada kutubxona xodimidan nafaqat fondni saqlash, balki resursni foydalanuvchi uchun tez topiladigan, tushunarli va qulay shaklda taqdim etish kompetensiyasi ham talab qilinadi.

Mazkur yondashuv Arnasoy tuman axborot-kutubxona markazi kabi hududiy axborot-kutubxona muassasalari uchun ham amaliy ahamiyatga ega. Fondni muntazam tahlil qilish, kitobxon talabini o‘rganish, yangi adabiyotlarni maqsadli tanlash va mavjud resurslarni elektron qidiruv imkoniyatlari bilan bog‘lash xizmatlarning sifatini oshirishga xizmat qiladi.

9. Amaliy tavsiyalar

• Kutubxona fondini foydalanuvchilarning real axborot ehtiyojlari asosida muntazam tahlil qilish va yangilash.

• Yangi kelib tushgan barcha hujjatlarni o‘z vaqtida hisobga olish, bibliografik ishlov berish va elektron katalogga kiritish.

• Bosma fondning jismoniy holatini davriy nazorat qilish, shikastlangan nashrlarni aniqlash va ta’mirlash choralarini ko‘rish.

• Raqamli resurslar uchun zaxira nusxalarini yaratish va fayllarni tizimli ravishda nazorat qilish.

• Elektron katalogdagi bibliografik yozuvlarni muntazam tekshirish va takroriy yozuvlarni kamaytirish.

• Kitobxonlar ehtiyojini so‘rovnoma, statistik ma’lumotlar va individual murojaatlar asosida o‘rganish.

• Yangi adabiyotlar ko‘rgazmalari, mavzuli bibliografik sharhlar va elektron tavsiya ro‘yxatlarini muntazam tashkil etish.

• Kutubxona xodimlarining raqamli va bibliografik kompetensiyalarini muntazam rivojlantirish.

• Fondni saqlash, undan foydalanish va raqamlashtirish jarayonlarini yagona ish rejasida o‘zaro bog‘lash.

Xulosa

Zamonaviy kutubxonada axborot-resurslarini saqlash va ulardan samarali foydalanish o‘zaro bog‘liq bo‘lgan ko‘p bosqichli jarayondir. Fondni to‘g‘ri shakllantirish, hujjatlarni hisobga olish va ularga sifatli bibliografik ishlov berish, bosma resurslarning jismoniy saqlanishini ta’minlash, raqamli resurslarni boshqarish hamda foydalanuvchilarga qulay axborot qidiruv imkoniyatlarini yaratish kutubxona faoliyatining yagona tizimini tashkil etadi.

Tadqiqot natijasida aniqlanishicha, o‘zbek kutubxonashunoslik adabiyotlarida fond, katalog, hujjatlarga ishlov berish va kitobxonlarga xizmat ko‘rsatish bo‘yicha muhim nazariy hamda amaliy asoslar shakllangan [1–4]. Ushbu asoslarni zamonaviy raqamli texnologiyalar bilan uyg‘unlashtirish kutubxona xizmatlarining samaradorligini oshirish imkonini beradi.

Kelgusida hududiy axborot-kutubxona markazlarida foydalanuvchilar ehtiyojini o‘rganish, fondlardan foydalanish statistikasi, raqamlashtirish samaradorligi va elektron kataloglardan foydalanish ko‘rsatkichlari asosida empirik tadqiqotlar olib borish maqsadga muvofiq. Bunday tadqiqotlar kutubxona resurslarini boshqarish bo‘yicha amaliy qarorlarni yanada asoslashga xizmat qiladi.

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Aholining salomatlik ko‘rsatkichlarini gigiyenik baholash

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Annotatsiya

Ushbu maqolada aholi salomatligini tavsiflovchi asosiy ko‘rsatkichlar, ularni yig‘ish, statistik tahlil qilish va gigiyenik jihatdan baholashning nazariy hamda amaliy asoslari yoritilgan. Aholining salomatlik holatini baholashda demografik ko‘rsatkichlar, kasallanish, o‘lim, chaqaloqlar va onalar o‘limi, o‘rtacha umr davomiyligi, nogironlik, jismoniy rivojlanish hamda tibbiy yordamdan foydalanish ko‘rsatkichlarining ahamiyati ko‘rib chiqilgan. Shuningdek, salomatlik ko‘rsatkichlarining atrof-muhit, turmush tarzi, ovqatlanish, mehnat sharoiti, ichimlik suvi va sanitariya-gigiyena holati bilan bog‘liqligi tahlil qilingan. Gigiyenik baholashda aholining turli guruhlari o‘rtasidagi farqlarni aniqlash, vaqt davomida dinamikani kuzatish va xavf omillarini baholash muhimligi asoslab berilgan.

Kalit so‘zlar: aholi salomatligi, gigiyenik baholash, kasallanish, o‘lim, demografik ko‘rsatkichlar, sanitariya, gigiyena, atrof-muhit, epidemiologiya, sog‘liqni saqlash.

Kirish

Aholi salomatligi jamiyatning ijtimoiy-iqtisodiy rivojlanishini belgilovchi muhim ko‘rsatkichlardan biridir. Aholining salomatlik darajasi nafaqat tibbiy xizmatlarning holatini, balki yashash muhiti, mehnat va dam olish sharoitlari, ovqatlanish sifati, ekologik vaziyat, sanitariya-obodonlashtirish darajasi hamda aholining turmush tarzini ham aks ettiradi. Shu sababli aholi salomatligini o‘rganish tibbiyotning alohida yo‘nalishi bilan cheklanib qolmay, gigiyena, epidemiologiya, demografiya, statistika va ijtimoiy tibbiyot bilan chambarchas bog‘liqdir.

Jahon sog‘liqni saqlash tashkiloti (JSST) sog‘liqni saqlash tizimlarini monitoring qilishda turli xil sog‘liq indikatorlaridan foydalanishni tavsiya qiladi. Bunday indikatorlar qatoriga umr davomiyligi, onalar va bolalar o‘limi, yuqumli va yuqumsiz kasalliklar, atrof-muhit xavflari, suv va sanitariya holati kabi ko‘rsatkichlar kiradi. JSSTning sog‘liq ko‘rsatkichlari bo‘yicha zamonaviy metodik hujjatlarida indikatorlarni aniqlash, tasniflash, tekshirish va statistik tahlil qilishga alohida e’tibor berilgan. Gigiyenik nuqtayi nazardan aholining salomatligini baholashning asosiy maqsadi mavjud salomatlik holatini aniqlash bilan birga, unga ta’sir qiluvchi muhit omillarini ham o‘rganishdir. Masalan, ichimlik suvining sifati, havoning ifloslanishi, oziq-ovqat xavfsizligi, uy-joy sharoiti va sanitariya infratuzilmasining holati aholining kasallanish darajasiga bevosita yoki bilvosita ta’sir ko‘rsatishi mumkin.

Tadqiqotning maqsadi

Aholining salomatlik ko‘rsatkichlarini gigiyenik baholashning asosiy mezonlarini o‘rganish, salomatlik holatini ifodalovchi ko‘rsatkichlarni tavsiflash hamda ularni yashash muhiti va gigiyenik omillar bilan bog‘liq holda tahlil qilish.

Tadqiqot vazifalari

Ushbu maqsadga erishish uchun quyidagi vazifalar belgilandi:

- aholining salomatligini ifodalovchi asosiy ko‘rsatkichlarni o‘rganish;
- demografik ko‘rsatkichlarning gigiyenik ahamiyatini aniqlash;
- kasallanish va o‘lim ko‘rsatkichlarini baholash;
- bolalar va onalar salomatligi ko‘rsatkichlarini tahlil qilish;
- jismoniy rivojlanish ko‘rsatkichlarining ahamiyatini ko‘rsatish;
- atrof-muhit va sanitariya-gigiyena omillarining aholi salomatligiga ta’sirini baholash;
- salomatlik ko‘rsatkichlarini statistik tahlil qilishning asosiy usullarini yoritish.

Aholi salomatligi tushunchasi va uning gigiyenik ahamiyati

Aholi salomatligi — ma’lum hududda yashovchi aholining jismoniy, ruhiy va ijtimoiy holatini ifodalovchi kompleks tushunchadir. Uni faqat kasalliklarning mavjud yoki mavjud emasligi bilan baholab bo‘lmaydi. Aholining salomatligi bir nechta o‘zaro bog‘liq ko‘rsatkichlar tizimi orqali tavsiflanadi. Gigiyena fanida salomatlikni o‘rganishda “aholi —

yashash muhiti — sog‘liq” tizimi muhim ahamiyatga ega. Inson organizmi doimiy ravishda tashqi muhit bilan aloqada bo‘ladi. Havo, suv, tuproq, oziq-ovqat, iqlim, shovqin, vibratsiya, radiatsiya, mehnat sharoiti va boshqa omillar organizmga ta’sir ko‘rsatadi.

Shuning uchun salomatlik ko‘rsatkichlarini baholashda faqat tibbiy statistik ma’lumotlarni emas, balki ekologik va gigiyenik ma’lumotlarni ham hisobga olish lozim. JSSTning zamonaviy sog‘liq indikatorlari tizimida sog‘liq natijalari bilan bir qatorda xavf omillari va sog‘liqni saqlash xizmatlaridan foydalanish ko‘rsatkichlari ham kuzatiladi. Bunda umr davomiyligi, sog‘lom umr davomiyligi, onalar va bolalar o‘limi, yuqumli kasalliklar, yuqumsiz kasalliklar, havo ifloslanishi va xavfsiz suv-sanitariya xizmatlaridan foydalanish kabi ko‘rsatkichlar alohida o‘rin tutadi.

Aholi salomatligining asosiy ko‘rsatkichlari

Aholining salomatligini gigiyenik baholashda ko‘rsatkichlarni bir necha asosiy guruhlarga ajratish mumkin:

- Demografik ko‘rsatkichlar.
- Kasallanish ko‘rsatkichlari.
- O‘lim ko‘rsatkichlari.
- Onalar va bolalar salomatligi ko‘rsatkichlari.
- Jismoniy rivojlanish ko‘rsatkichlari.
- Nogironlik ko‘rsatkichlari.
- Aholining tibbiy yordamdan foydalanish ko‘rsatkichlari.
- Hayot sifati va sog‘lom umr davomiyligi ko‘rsatkichlari.

Mazkur ko‘rsatkichlar birgalikda baholanganda aholining salomatlik holati haqida ancha to‘liq tasavvur hosil qilish mumkin.

Demografik ko‘rsatkichlar

Demografik ko‘rsatkichlar aholi tarkibi va tabiiy harakatini ifodalaydi. Ularning asosiylariga tug‘ilish, o‘lim, tabiiy o‘sish, nikoh, ajralish, migratsiya, yosh va jins tarkibi kiradi.

Tug‘ilish koeffitsiyenti ma’lum davrda tug‘ilgan bolalar sonining o‘rtacha aholiga nisbati orqali aniqlanadi:

Tug‘ilish koeffitsiyenti = tug‘ilganlar soni / o‘rtacha aholi soni × 1000.

O‘lim koeffitsiyenti esa ma’lum davrdagi vafot etganlar sonining o‘rtacha aholi soniga nisbati bilan hisoblanadi:

O‘lim koeffitsiyenti = vafot etganlar soni / o‘rtacha aholi soni × 1000.

Tabiiy o‘sish tug‘ilish va o‘lim ko‘rsatkichlari o‘rtasidagi farq bilan belgilanadi.

Demografik ko‘rsatkichlarni gigiyenik baholashda aholining yosh-jins tarkibini hisobga olish juda muhim. Chunki yosh tarkibi turlicha bo‘lgan hududlarda umumiy o‘lim yoki kasallanish ko‘rsatkichlarini to‘g‘ridan-to‘g‘ri taqqoslash noto‘g‘ri xulosalarga olib kelishi mumkin. Shu sababli standartlashtirilgan ko‘rsatkichlardan foydalanish maqsadga muvofiq.

Kasallanish ko‘rsatkichlari

Aholi salomatligini tavsiflovchi eng muhim ko‘rsatkichlardan biri kasallanishdir. Kasallanish deganda ma’lum hudud va ma’lum vaqt oralig‘ida aholida aniqlangan kasalliklar majmui tushuniladi.

Kasallanishni baholashda quyidagi ko‘rsatkichlar qo‘llanadi:

- birlamchi kasallanish;
- umumiy kasallanish;
- alohida kasalliklarning tarqalganligi;
- yuqumli kasallanish;
- vaqtinchalik mehnatga layoqatsizlik bilan kechadigan kasallanish;
- kasalliklarning yosh va jins bo‘yicha taqsimlanishi.

Birlamchi kasallanish ma’lum davr davomida aholida birinchi marta aniqlangan kasalliklar sonini ifodalaydi.

Umumiy kasallanish esa tibbiy muassasalarga murojaatlar yoki tibbiy kuzatuv natijasida qayd etilgan kasalliklarning umumiy miqdorini tavsiflaydi. Kasallanish ko‘rsatkichlarini gigiyenik baholashda kasalliklarning tuzilmasiga alohida e’tibor beriladi. Masalan, nafas olish tizimi kasalliklarining yuqori ulushi havo ifloslanishi, ishlab chiqarish changlari, kimyoviy moddalar yoki mikroiqlim sharoitlari bilan bog‘liq bo‘lishi mumkin. Biroq bunday bog‘liqlikni aniqlash uchun epidemiologik va statistik tadqiqotlar orqali boshqa omillar ham hisobga olinishi kerak. Yuqumsiz kasalliklar — yurak-qon tomir kasalliklari, qandli diabet, saraton, surunkali nafas olish kasalliklari va

boshqalar — ham aholining salomatlik holatini baholashda muhim o‘rin egallaydi. JSST sog‘liq indikatorlari tizimida yuqumsiz kasalliklar, ularning xavf omillari va muddatidan oldingi o‘lim ko‘rsatkichlari alohida monitoring qilinadi.

O‘lim ko‘rsatkichlarini gigiyenik baholash

O‘lim ko‘rsatkichi aholi salomatligining eng muhim integral ko‘rsatkichlaridan hisoblanadi. Uni umumiy va maxsus ko‘rsatkichlarga ajratish mumkin. Umumiy o‘lim koeffitsiyenti aholining barcha guruhlari bo‘yicha o‘lim darajasini ko‘rsatadi. Maxsus o‘lim ko‘rsatkichlari esa yosh, jins yoki o‘lim sababiga ko‘ra hisoblanadi.

Masalan: **Yosh guruhiga xos o‘lim koeffitsiyenti = ma’lum yosh guruhidagi vafot etganlar soni / shu yosh guruhidagi aholi soni × 1000.**

O‘lim sabablarini tahlil qilish gigiyenik jihatdan katta ahamiyatga ega. Chunki o‘limning asosiy sabablarini aniqlash profilaktika choralarini rejalashtirishga yordam beradi. O‘lim ko‘rsatkichlarining yuqoriligi har doim ham yashash sharoitining yomonligini anglatmaydi. Masalan, aholining yosh tarkibi “qarigan” hududlarda umumiy o‘lim ko‘rsatkichi yosh aholi ko‘p bo‘lgan hududlarga qaraganda yuqori bo‘lishi mumkin. Shu sababli taqqoslashda yosh bo‘yicha standartlashtirishdan foydalanish kerak.

Chaqaloqlar va bolalar salomatligi ko‘rsatkichlari

Bolalar salomatligi jamiyat salomatligining muhim indikatoridir. Ayniqsa, chaqaloqlar o‘limi, neonatal o‘lim, 5 yoshgacha bo‘lgan bolalar o‘limi, tug‘ruqdagi asoratlar va bolalarning jismoniy rivojlanishi muhim ahamiyatga ega.

Chaqaloqlar o‘limi koeffitsiyenti odatda bir yoshga yetmasdan vafot etgan bolalar sonining tirik tug‘ilganlar soniga nisbati orqali baholanadi. JSSTning sog‘liqni monitoring qilish tizimida neonatal va 5 yoshgacha bo‘lgan bolalar o‘limi asosiy natijaviy indikatorlar qatoriga kiritilgan. Bolalar o‘limiga ijtimoiy-iqtisodiy sharoit, onaning salomatligi, homiladorlikni olib borish sifati, tug‘ruq sharoitlari, ovqatlanish, yuqumli kasalliklar, ichimlik suvi sifati va sanitariya sharoitlari ta’sir qilishi mumkin. Shu sababli bolalar salomatligi ko‘rsatkichlari hududning sanitariya-gigiyenik holatini baholashda ham muhim indikator hisoblanadi.

Onalar salomatligi ko‘rsatkichlari

Onalar salomatligi jamiyatning tibbiy va ijtimoiy rivojlanganlik darajasini aks ettiruvchi muhim yo‘nalishlardan biridir.

Onalar salomatligini baholashda:

- onalar o‘limi;
- homiladorlik davridagi asoratlar;
- tug‘ruq asoratlari;
- prenatal tibbiy yordamdan foydalanish;
- malakali tibbiy xodim tomonidan tug‘ruqni qabul qilish;
- reproduktiv salomatlik ko‘rsatkichlari kabi indikatorlar qo‘llanadi.

Onalar o‘limining sabablari tibbiy yordam sifati bilan birga ijtimoiy va gigiyenik sharoitlar bilan ham bog‘liq bo‘lishi mumkin. Shu sababli onalar salomatligini baholash kompleks yondashuvni talab qiladi.

Aholining jismoniy rivojlanishini baholash

Jismoniy rivojlanish organizmning o‘sishi va shakllanishini ifodalovchi muhim biologik ko‘rsatkichdir. Ayniqsa, bolalar va o‘smirlarning jismoniy rivojlanishini o‘rganishda uning ahamiyati katta. Asosiy antropometrik ko‘rsatkichlarga:

- bo‘y uzunligi;
- tana vazni;
- ko‘krak qafasi aylanasi;
- tana massasi indeksi;
- mushak kuchi;
- o‘pkaning tiriklik sig‘imi kabilar kiradi.

Bolalarning jismoniy rivojlanishi ovqatlanish, jismoniy faollik, uyqu, kun tartibi, ekologik sharoit, ijtimoiy-iqtisodiy holat va boshqa omillarga bog‘liq.

Jismoniy rivojlanish ma’lumotlarini baholashda yosh va jinsga mos standartlardan foydalanish zarur. Bir guruhdagi o‘rtacha qiymatning o‘zi bolaning individual salomatligini to‘liq ifodalamasligi mumkin.

Gigiyenik omillar va aholi salomatligi

Aholi salomatligining shakllanishida yashash muhiti muhim o‘rin tutadi. Gigiyenik baholashda quyidagi muhit omillariga alohida e’tibor beriladi:

Atmosfera havosi: Atmosfera havosining chang, azot oksidlari, oltingugurt birikmalari, uglerod oksidi, mayda dispers zarrachalar va boshqa ifloslantiruvchilar bilan ifloslanishi aholi salomatligiga salbiy ta’sir ko‘rsatishi mumkin. Shuning uchun havo sifatini baholashda ifloslantiruvchi moddalar konsentratsiyasi, ularning me’yoriy qiymatlarga nisbati va aholining ekspozitsiyasi hisobga olinadi.

Ichimlik suvi: Ichimlik suvining epidemiologik va kimyoviy xavfsizligi aholi salomatligi uchun muhimdir. Suvning mikrobiologik ifloslanishi ichak infeksiyalari xavfini oshirishi mumkin. JSST ma’lumotlariga ko‘ra, xavfsiz ichimlik suvi, sanitariya va gigiyena xizmatlari aholining salomatligini himoya qilishda muhim omillardir.

Sanitariya sharoitlari: Sanitariya infratuzilmasining yetarli emasligi yuqumli kasalliklarning tarqalishi, ovqatlanish va bolalar salomatligi bilan bog‘liq muammolar xavfini oshirishi mumkin. JSST sanitariya xizmatlaridan foydalanishni sog‘liq va ijtimoiy rivojlanishni monitoring qilishda muhim indikator sifatida ko‘rsatadi.

Uy-joy sharoitlari; Uy-joyning maydoni, shamollatilishi, tabiiy va sun’iy yoritilishi, mikroiqlim, namlik, isitish tizimi, shovqin darajasi va sanitariya holati inson salomatligiga ta’sir qiluvchi omillar hisoblanadi.

Ovqatlanish; Aholining ovqatlanish sifati salomatlikning asosiy determinantlaridan biridir. Ratsionning energiya qiymati, oqsil, yog‘, uglevod, vitamin va mineral moddalarning yetarliligi hamda ovqatlanish rejimi baholanadi. Noto‘g‘ri ovqatlanish semirish, yurak-qon tomir kasalliklari, qandli diabet va boshqa surunkali kasalliklarning rivojlanish xavfi bilan bog‘liq bo‘lishi mumkin.

Sanitariya-gigiyenik sharoitlarni baholash: Aholi salomatligini gigiyenik baholashda WASH — suv, sanitariya va shaxsiy gigiyena ko‘rsatkichlari alohida ahamiyatga ega. JSSTning Global Health Observatory tizimida “kamida asosiy sanitariya xizmatlaridan foydalanayotgan aholi ulushi” alohida indikator sifatida yuritiladi. Ushbu indikator yaxshilangan sanitariya inshootlaridan foydalanadigan va ularni boshqa xo‘jaliklar bilan bo‘lishmaydigan aholi ulushini ifodalaydi. 2022-yilda dunyo aholisining 57 foizi xavfsiz boshqariladigan sanitariya xizmatlaridan foydalangan. Shu bilan birga, 1,5 milliarddan ortiq odam hali ham asosiy sanitariya xizmatlaridan to‘liq foydalana olmagan. JSST sanitariya sharoitlarining yetarli emasligini diareya, vabo, dizenteriya, ichak parazitar kasalliklari va boshqa salomatlik muammolari bilan bog‘laydi. Gigiyenik baholashda quyidagi mezonlarni o‘rganish mumkin:

Ichimlik suvi; aholining xavfsiz ichimlik suvi bilan ta’minlanganlik darajasi;

- kanalizatsiya tizimining mavjudligi;
- chiqindilarni yig‘ish va utilizatsiya qilish holati;
- uy-joylarning sanitariya holati;
- qo‘l yuvish uchun sharoitlarning mavjudligi;
- maktab va ish joylaridagi sanitariya sharoitlari;
- oziq-ovqat mahsulotlarining sanitariya xavfsizligi.

Salomatlik ko‘rsatkichlarini statistik baholash

Aholi salomatligi ko‘rsatkichlarini to‘g‘ri baholash uchun statistik usullardan foydalanish zarur.

Asosiy statistik usullar quyidagilardan iborat:

- mutlaq qiymatlarni hisoblash;
- nisbiy ko‘rsatkichlarni aniqlash;
- intensiv koeffitsiyentlarni hisoblash;
- ekstensiv ko‘rsatkichlarni aniqlash;
- o‘rtacha qiymatlarni hisoblash;
- dinamik qatorlarni tahlil qilish;
- standartlashtirish;
- korrelyatsion tahlil;
- statistik ishonchlilikni baholash.

Intensiv ko‘rsatkich hodisaning muhitga yoki aholiga nisbatan tarqalishini ko‘rsatadi. Masalan, 1000 yoki 100 000 aholiga to‘g‘ri keladigan kasallanish soni.

Ekstensiv ko‘rsatkich esa hodisaning tarkibini ifodalaydi. Masalan, barcha kasalliklar tarkibida yurak-qon tomir kasalliklarining foizdagi ulushi.

Turli hududlarni taqqoslashda aholining yosh va jins tarkibi bir xil bo‘lmasa, standartlashtirish usulidan foydalanish kerak. Bu usul demografik tarkibdagi farqlarning statistik natijaga ta’sirini kamaytirishga yordam beradi. JSSTning 2025-yilda chop etilgan sog‘liq ma’lumotlari, statistika va sog‘liq indikatorlari lug‘ati indikatorlarni aniqlash, tasniflash, tahlil qilish va validatsiya qilish uchun standart terminologiyani taqdim etadi.

Salomatlik ko‘rsatkichlarini hududlar bo‘yicha baholash

Aholining salomatligini gigiyenik baholashda hududiy taqqoslash muhim metodlardan biridir. Masalan, sanoat rivojlangan hududdagi kasallanish ko‘rsatkichlarini qishloq xo‘jaligiga ixtisoslashgan hudud ko‘rsatkichlari bilan solishtirish mumkin.

Biroq bunday taqqoslashda quyidagi omillar hisobga olinishi lozim:

- aholining yosh tarkibi;
- jinsiy tarkibi;
- urbanizatsiya darajasi;
- ijtimoiy-iqtisodiy sharoit;
- tibbiy yordamning mavjudligi;
- diagnostika imkoniyatlari;
- ekologik sharoit;
- aholi migratsiyasi;
- statistik ma’lumotlarning to‘liqligi.

Aholining kasallanish darajasi yuqori bo‘lgan hududda tibbiy xizmatlarning yaxshi yo‘lga qo‘yilgani sababli kasalliklar ko‘proq aniqlanishi ham mumkin. Shuning uchun faqat bitta ko‘rsatkich asosida hududning gigiyenik holati to‘g‘risida yakuniy xulosa chiqarish to‘g‘ri emas.

Salomatlik ko‘rsatkichlarini kompleks gigiyenik baholash

Kompleks baholashda salomatlik ko‘rsatkichlari va ularga ta’sir qiluvchi gigiyenik omillar birgalikda o‘rganiladi. Masalan, ma’lum hududda nafas olish tizimi kasalliklari ko‘paygan bo‘lsa, quyidagi ma’lumotlarni birgalikda tahlil qilish maqsadga muvofiq:

- Atmosfera havosidagi ifloslantiruvchi moddalar miqdori.
- Sanoat korxonalari soni va faoliyati.
- Avtotransport zichligi.
- Aholining yosh va jins tarkibi.
- Chekish tarqalganligi.
- Tibbiy yordamga murojaat qilish darajasi.
- Kasalliklarni aniqlash va ro‘yxatga olish sifati.
- Kasallanishning yillar bo‘yicha dinamikasi.

Shunday kompleks tahlil kasallik ko‘rsatkichlarining ehtimoliy xavf omillari bilan bog‘liqligini aniqlash imkonini beradi.

Gigiyenik baholashning amaliy ahamiyati

Aholining salomatlik ko‘rsatkichlarini gigiyenik baholash amaliy sog‘liqni saqlash uchun bir qator muhim vazifalarni hal qilish imkonini beradi. Birinchidan, kasalliklarning hududiy va yosh-jins bo‘yicha tarqalishini aniqlash mumkin. Ikkinchidan, salomatlikka salbiy ta’sir qiluvchi ekologik va ijtimoiy omillarni aniqlashga imkon beradi. Uchinchidan, profilaktik tadbirlarning ustuvor yo‘nalishlarini belgilash mumkin. To‘rtinchidan, sanitariya-gigiyena tadbirlarining samaradorligini vaqt davomida baholash mumkin. Beshinchidan, sog‘liqni saqlash resurslarini aholining real ehtiyojlariga muvofiq rejalashtirish imkoniyati paydo bo‘ladi. JSSTning birlamchi tibbiy yordamni monitoring qilish tizimida sog‘liq natijalari bilan birga xizmat qamrovi, tenglik, sifat va sog‘liq determinantlarini birgalikda kuzatish tavsiya qilinadi.

Xulosa aytganda, aholining salomatlik ko‘rsatkichlarini gigiyenik baholash sog‘liqni saqlash, gigiyena va epidemiologiya amaliyotining muhim yo‘nalishlaridan biridir. Aholi salomatligini to‘g‘ri baholash uchun faqat kasallanish yoki o‘lim ko‘rsatkichlarini o‘rganish yetarli emas. Demografik holat, jismoniy rivojlanish, onalar va

bolalar salomatligi, nogironlik, hayot davomiyligi, tibbiy yordamdan foydalanish imkoniyati hamda yashash muhitining sanitariya-gigiyenik holati kompleks tarzda tahlil qilinishi lozim. Gigiyenik baholashning muhim jihati — salomatlik ko‘rsatkichlarini ularga ta’sir qiluvchi tashqi muhit omillari bilan birgalikda o‘rganishdir. Havo va suv sifati, sanitariya, chiqindilarni boshqarish, uy-joy sharoitlari, ovqatlanish, mehnat sharoitlari va turmush tarzi aholining salomatlik holatini shakllantiruvchi muhim determinantlardir. Salomatlik indikatorlarini to‘g‘ri tanlash va standart metodlar asosida hisoblash hududlar o‘rtasida ishonchli taqqoslash olib borish imkonini beradi. JSST sog‘liq indikatorlarini standartlashtirish, ularni muntazam monitoring qilish va turli darajalarda — mahalliy, milliy va xalqaro miqyosda — taqqoslash uchun indikatorlar tizimidan foydalanadi.

Shunday qilib, aholining salomatlik ko‘rsatkichlarini gigiyenik baholash profilaktik tibbiyotning muhim vositasi bo‘lib, kasalliklarning oldini olish, sog‘lom turmush tarzini shakllantirish, yashash muhitini yaxshilash va aholining hayot sifatini oshirishga qaratilgan tadbirlarni ilmiy asoslash imkonini beradi.

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A Traffic-Actuated Electromechanical Road Harvester for Generating Electricity from Passing Vehicles: Design Concept, Analytical Energy Model and Comparison with Published Roadway Harvesters

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Abstract

Road traffic dissipates part of the vehicle energy in pavement deformation and braking, yet road-side electrical loads are still supplied by cables or batteries. This paper describes an electromechanical road energy harvester protected by the Uzbek invention patent No. IAP 8475 (priority date 13 December 2025). The wheel load of a passing vehicle depresses a spring-returned top plate, and a rack-and-pinion, an overrunning clutch and a speed-increasing gear train drive a flywheel-coupled permanent-magnet synchronous generator whose output is rectified and stored. A closed-form estimate of the recovered electrical energy, $E_{el} = \eta_{tot} mgs$, is derived and evaluated for three vehicle classes and plate strokes of 10–20 mm. With an assumed overall conversion efficiency of 0.52 and a 15 mm stroke, the model gives about 115 J per 1.5 t passenger car, 268 J per 3.5 t light commercial vehicle and 1.53 kJ per 20 t truck. For a mixed flow of 5000 vehicles per day, the recovered energy is about 0.22 kWh/day, and about 11 100 vehicles per day are needed to supply one 40 W LED lamp for 12 h. The energy taken from a vehicle equals $2gs/v^2$ of its kinetic energy, about 1% at 20 km/h. The model is compared with 18 published studies of piezoelectric, electromagnetic, triboelectric, thermoelectric, wind and vehicle-mounted harvesters retrieved from PubMed. Displacement-type electromechanical harvesting recovers several orders of magnitude more energy per vehicle than pavement-embedded piezoelectric devices, but it takes this energy from the vehicle and is therefore suited to sites where traffic must slow down anyway.

Keywords: Electromagnetic generator, energy harvesting, rack-and-pinion mechanism, road infrastructure, speed bump, traffic-induced energy.

I. Introduction

Road networks carry a growing number of electrical loads: street and crossing lighting, illuminated signs, traffic counters, weigh-in-motion stations and pavement condition sensors. Zheng *et al.* [1] identify the power supply of distributed sensor networks as the main bottleneck of intelligent roads, because cabled supply is costly to extend and batteries have short service lives and high maintenance costs; the same review concludes that current road micro-energy harvesting technologies cannot yet meet the demand of large-scale sensor networks [1]. Harvesting part of the mechanical energy that vehicles already deliver to the road is one way to supply such loads locally.

The conversion principles available for this purpose (photovoltaic, electromagnetic, piezoelectric, triboelectric, thermoelectric and others) were surveyed by Bai *et al.* [2]. The following subsections review how these principles have been applied to road traffic and identify the gap addressed here.

A. Road-Embedded Harvesters

Piezoelectric transducers embedded in the pavement have received the most study. Li *et al.* [3] developed a device made of stacked piezoelectric units that delivered 84.3 mW at a 10 kN, 10 Hz load, kept its electrical properties after 100 000 load cycles and produced an open-circuit voltage of 190 V under a real tire load; traffic parameters could also be extracted from its voltage waveform. Yang *et al.* [4] studied how the connection mode, the number of stack layers, the height-to-area ratio and the number of units affect the output of stack harvesters under accelerated pavement testing. Finite-element studies showed that the voltage depends on the embedding depth and on the horizontal distance between the tire and the transducer [5], and that distributing more, smaller piezoelectric units in a 30 cm × 30 cm harvester increases the energy but also the stress concentration near the edges [6]. Vázquez-Rodríguez *et al.* [7] built a programmable traffic-simulating test bench whose models predicted the harvested power with a relative error below

3%, and compared lead-containing and lead-free piezoceramics. Flexible composite films placed at the roadside have been tested under motorcycles and bicycles [8].

Other road-embedded principles have lower outputs. A thermoelectric cement composite reinforced with carbon nanotubes and $Bi_{0.5}Sb_{1.5}Te_3$ improved its figure of merit by a factor of 842 but still generated only 0.002 µW at a temperature difference of 19.1 K [9]. Triboelectric nanogenerators have been reviewed for vehicle vibration, wheel–road and on-board applications, where they serve mainly as self-powered sensors [10].

A common limitation of pavement-embedded harvesters is that they operate at the small deflections of a stiff pavement, so the energy recovered per vehicle is small. In a field installation with 16 piezoelectric cantilevers, Heller *et al.* [11] measured a peak power of 55.6 µW per transducer and estimated a generation capacity of about 50 mWh per month for a traffic volume of 1500 vehicles per day. Dipon *et al.* [12] reported that only 0.25% of the mechanical power of passing vehicles reached their stacked piezoelectric harvester. Electromagnetic harvesters deliver higher power but have been described as bulky and as requiring large input displacements [13]; Mou *et al.* [13] addressed this with a pavement harvester that uses frequency up-conversion and unidirectional rotation and reached 171.14 mW in laboratory tests.

B. Vehicle-Mounted and Road-Side Harvesters

A second line of work recovers energy on board the vehicle, mainly through regenerative shock absorbers. A Monte Carlo study of a quarter-car model found that the harvestable power bandwidth was most sensitive to the excitation, the damping rate and the tire properties, and hardly changed with the body and wheel masses or the spring stiffness [14]. Reyes-Avendaño *et al.* [15] showed that a ball-screw regenerative damper can replicate a passive damper curve only above a minimum damper velocity, and noted that no commercial energy-harvesting shock absorber existed at the time of their study. In simulation, an optimal linear-quadratic control law increased the harvested energy by 37.3% and 27.8% compared with two reference strategies [16]. Piezoelectric patches on the tire inner liner generated voltages that increased with patch size, speed and normal load [17]. Road-side wind is a further source: a hybrid turbine that starts at low wind speed has been developed for urban self-powered sensing [18], and a triboelectric wind harvester has been used to power a traffic light system [19].

C. Research Gap and Contributions

Among the records retrieved for this study (Section II-D), none described an electromechanical harvester with a stroke of the order of 10 mm installed at a traffic-calming location, and the reported outputs of road harvesters are given in units that are difficult to compare (peak power, open-circuit voltage, energy per month or efficiency). This paper addresses both points. Its contributions are: (i) a description of the traffic-actuated electromechanical harvester of patent IAP 8475 [20]; (ii) a closed-form model of the electrical energy recovered per vehicle and per day, with explicit assumptions and a sensitivity range; (iii) a comparison of the model with published road, wind and vehicle-mounted harvesters on a common per-vehicle basis; and (iv) siting and design implications. Section II describes the device, the model and the literature analysis, Section III reports the results, Section IV discusses them and Section V concludes the paper.

II. Materials and Methods

A. Device Description

The harvester is a steel housing installed flush with the road surface across the traffic lane, so that both wheels of each axle load it (Fig. 1). A top plate with a profiled upper surface protrudes above the road by the working stroke s and is guided vertically; return springs lift it back after each axle has passed. A toothed rack fixed to the underside of the plate engages a pinion of pitch radius r_p on the input shaft. An overrunning (one-way) clutch transmits torque only during the downward stroke, so the shaft always turns in one direction, and a gear train with speed ratio i drives a flywheel and a three-phase permanent-magnet synchronous generator (PMSG). During the return stroke, the clutch disengages, and the flywheel keeps the generator turning between axles. The generator output is rectified, conditioned by a DC–DC converter that tracks the maximum power point and stored in a battery, which supplies roadside loads such as LED lighting, illuminated signs and sensors.

The combination of unidirectional rotation and frequency up-conversion was chosen because it allowed a small electromagnetic pavement harvester to convert a short reciprocating input into continuous rotation with high output power in the tests of Mou *et al.* [13]. The device described here applies the same principle at a stroke of the order of 10 mm, which is comparable with the height of a low-speed bump, instead of the few millimetres of pavement deflection.

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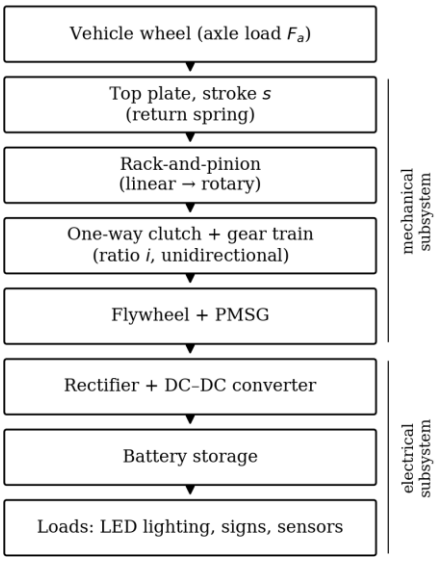


Fig. 1. Energy conversion chain of the traffic-actuated electromechanical harvester. PMSG: permanent-magnet synchronous generator.

B. Analytical Energy Model

When an axle with static load F_a rolls onto the plate, the plate moves down by s against the reaction force $F_r(x)$ of the springs and of the generator reflected through the gear train. Because the plate cannot support more than the axle load, the mechanical work delivered per axle is bound by

$$W_a = \int_0^s F_r(x)\,dx \le F_a s. \tag{1}$$

Summing over the axles of a vehicle and using the fact that the static axle loads add up to the vehicle weight gives, for a vehicle of mass m,

$$W_v \le \Sigma_k F_{a,k} s = mgs. \tag{2}$$

The bound mgs have a simple interpretation: it equals the change in potential energy of the vehicle if its whole weight were lowered by the stroke s. In practice, the vehicle does not lose height permanently; the work is supplied from its kinetic energy as the wheels roll over the plate edge, which is why the loss is expressed as a share of kinetic energy in (6) below.

The recovered electrical energy per vehicle is then

$$E_{el} = \eta_{tot} mgs,\ \eta_{tot} = \lambda \eta_m \eta_g \eta_c, \tag{3}$$

where λ is the fraction of the bound (2) that becomes shaft work (it accounts for spring preload, plate inertia and incomplete strokes), and η_m, η_g and η_c are the efficiencies of the mechanical transmission, the generator and the power electronics. For a traffic flow of N vehicles per day in which class j has share p_j and mass m_j, the daily energy is

$$E_d = N \eta_{tot} gs\ \Sigma_j\ p_j m_j. \tag{4}$$

The kinematics of one stroke follow from the plate length L_p along the road and the vehicle speed v. The stroke time and the mean generator speed during the stroke are

$$t_p \approx L_p / v,\ \omega_g \approx is/(r_p t_p), \tag{5}$$

and the fraction of the vehicle kinetic energy that the harvester removes is

$$\xi = mgs/(\tfrac{1}{2} m v^2) = 2gs/v^2, \tag{6}$$

which does not depend on the vehicle mass. The parameter values are listed in Table I. The efficiencies are design assumptions taken as typical of gear transmissions, small PMSGs and switching converters; they were not measured on the device, and the daily energy is therefore also reported for η_{tot} between 0.30 and 0.60. The model uses static axle loads and ignores dynamic load amplification, tire enveloping and lateral wheel wander. A one-at-a-time sensitivity analysis varied each parameter between the limits given in Section III-G while keeping the others at their baseline values.

Table I. Model Parameters

Parameter	Symbol	Value
Plate stroke	s	10, 15, 20 mm
Plate length along the road	L_p	0.30 m
Pinion pitch radius	r_p	10 mm
Gear train speed ratio	i	20
Stroke utilisation factor	λ	0.80
Transmission efficiency	η_m	0.85
Generator efficiency	η_g	0.85
Power electronics efficiency	η_c	0.90
Overall efficiency (baseline)	η_{tot}	0.52
Vehicle speed over the plate	v	20 km/h
Traffic mix: car / light commercial / truck	p_j	0.90 / 0.08 / 0.02
Class masses	m_j	1.5 / 3.5 / 20 t

C. Transmission, Flywheel and Storage Sizing

The mean reaction force on the rack during a stroke is λF_a. The resulting pinion torque and the torque at the generator shaft are

$$T_p = \lambda F_a r_p,\ T_g = \eta_m T_p / i. \tag{7}$$

The flywheel must absorb the shaft work of one axle stroke, $W_{sh} = \lambda \eta_m F_a s$, while its speed falls from ω_{max} to $k\omega_{max}$ between axles. Its moment of inertia must therefore satisfy

$$J_f \geq 2W_{sh}/[\omega_{max}^2(1 - k^2)]. \tag{8}$$

A battery that supplies a daily load energy E_L at nominal voltage U with an allowed depth of discharge D needs a capacity

$$C = E_L/(UD). \tag{9}$$

For the sizing example, ω_{max} was taken as the mean generator speed from (5), k = 0.8, E_L = 0.48 kWh (one 40 W LED lamp for 12 h), U = 12.8 V (four lithium iron cells in series) and D = 0.8.

D. Literature Analysis

Published harvesters were identified in PubMed in September 2026 with two structured queries: (a) road, pavement, roadway, traffic, vehicle, speed bump or deceleration in the title combined with energy harvesting, harvester or harvesters in the title; and (b) pavement, asphalt or traffic load in the title or abstract combined with piezoelectric, electromagnetic, triboelectric or energy harvesting in the title. The queries returned 33 unique records. A similarity search seeded with the electromagnetic pavement harvester of [13] added 15 candidates. Titles and abstracts of the 48 records were screened. Studies were retained if they reported measured or simulated results for a road, traffic or vehicle-mounted harvester, or for a transducer principle directly applicable to one; records on electromagnetic shielding, ground-penetrating radar, asphalt heating and weigh-in-motion sensing without energy output were excluded. Eighteen primary studies were retained, and three reviews [1], [2], [10] were used for background. For each primary study, the transduction principle, the placement, the excitation, the reported output with its test conditions and whether the device was tested under real traffic were extracted as reported by the authors.

III. Results

A. Energy per Vehicle

Table II and Fig. 2 give the electrical energy per vehicle from (3). Energy grows linearly with vehicle mass and stroke. At the baseline stroke of 15 mm a passenger car yields 114.8 J, a light commercial vehicle 267.9 J and a heavy truck 1530.9 J. Reducing the stroke to 10 mm lowers these values by one third, to 76.5 J, 178.6 J and 1020.6 J; a 20 mm stroke raises them to 153.1 J, 357.2 J and 2041.3 J. Because heavy vehicles carry most of the load, the 2% truck share contributes about 20% of the mean energy per vehicle in the baseline traffic mix.

Table II. Electrical Energy per Vehicle (J) at Overall Efficiency 0.52

Vehicle class	s = 10 mm	s = 15 mm	s = 20 mm
Passenger car, 1.5 t	76.5	114.8	153.1
Light commercial, 3.5 t	178.6	267.9	357.2
Heavy truck, 20 t	1020.6	1530.9	2041.3
Traffic-mix mean	103.6	155.4	207.2

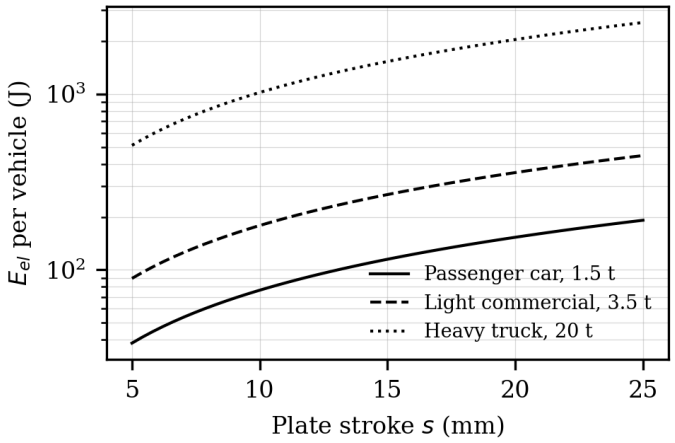


Fig. 2. Electrical energy recovered per vehicle as a function of plate stroke for three vehicle classes (baseline η_{tot} = 0.52; logarithmic scale).

B. Stroke Kinematics and Power

At 20 km/h and a plate length of 0.30 m, (5) gives a stroke time of about 0.054 s. With r_p = 10 mm, the pinion turns through 1.5 rad per 15 mm stroke, and with i = 20 the generator completes about 4.8 revolutions per axle, at a mean speed of about 555 rad/s (5300 r/min) during the stroke. The mean electrical power during the stroke of one passenger-car axle is about 1.06 kW. The harvester therefore receives short pulses of the order of a kilowatt lasting ten milliseconds, separated by idle intervals that depend on traffic headway.

C. Daily Energy

With the traffic mix of Table I, the mean energy per vehicle is 155.4 J. Fig. 3 shows the daily energy from (4). At 5000 vehicles per day the harvester delivers about 0.22 kWh/day (0.12–0.25 kWh/day across the efficiency range); at 10 000 vehicles per day, 0.43 kWh/day; and at 20 000 vehicles per day, 0.86 kWh/day. A 40 W LED lamp operated for 12 h consumes 0.48 kWh, which requires about 11 100 vehicles per day at the baseline efficiency and a stroke of 15 mm.

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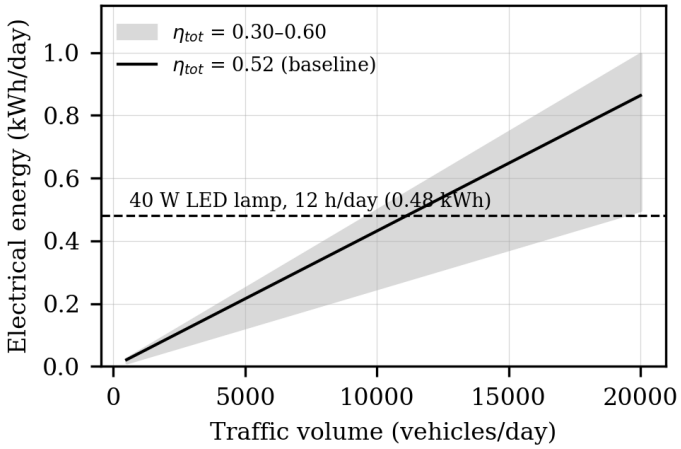


Fig. 3. Daily electrical energy versus traffic volume for the mix of Table I and s = 15 mm. The shaded band covers η_{tot} = 0.30–0.60; the dashed line is the daily consumption of one 40 W LED lamp operated 12 h.

D. Energy Taken from the Vehicle

From (6), a 15 mm stroke removes 3.8% of the kinetic energy of a vehicle at 10 km/h, 0.95% at 20 km/h and 0.42% at 30 km/h, for any vehicle mass. For a 1.5 t car at 20 km/h this is 221 J of mechanical work out of a kinetic energy of 23.1 kJ.

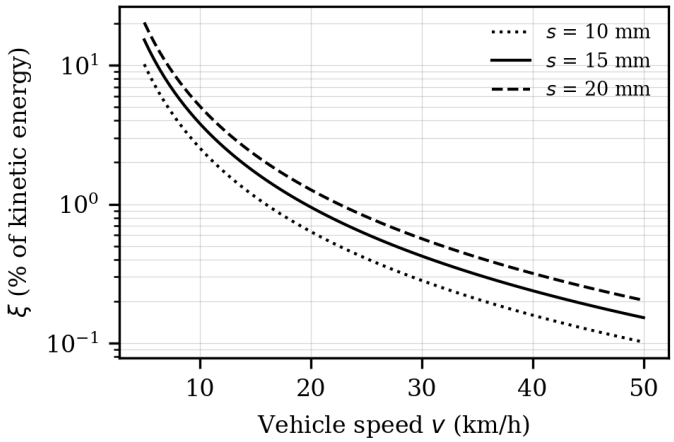


Fig. 4. Share of vehicle kinetic energy removed by one pass over the harvester, from (6), for three plate strokes (logarithmic scale). The share is independent of vehicle mass.

Fig. 4 shows that the share falls with the square of speed. At 40 km/h a 15 mm stroke removes 0.24% of the kinetic energy, but a vehicle crossing a raised plate at that speed would experience a vertical jolt; the useful operating range is therefore the low-speed range typical of traffic-calming locations.

E. Component Loads and Storage

From (7), a passenger-car axle produces a pinion torque of 58.9 N·m and a generator shaft torque of 2.50 N·m. A 3.5 t light commercial vehicle gives 137.3 N·m and 5.84 N·m, and a 20 t truck axle gives 523.2 N·m and 22.24 N·m. The shaft work per car axle at s = 15 mm is 75.0 J; with ω_{max} = 555 rad/s and k = 0.8, (8) gives a flywheel inertia of 1.35×10^{-3} kg·m^2, which a steel disc of 0.06 m radius and about 0.75 kg provides. From (9), storing one lamp-night of 0.48 kWh requires a battery of about 47 A·h at 12.8 V.

F. Site Scenarios

Table IV applies (4) to five traffic volumes representing typical installation sites. The annual energy ranges from 15.8 kWh at 1000 vehicles per day to 315.1 kWh at 20 000 vehicles per day, equivalent to between 33 and 656 nights of operation of one 40 W LED lamp.

Table IV. Energy Yield for Representative Traffic Volumes (s = 15 mm, Baseline Efficiency)

Traffic (veh/day)	kWh/day	kWh/year	Lamp-nights/year
1000	0.043	15.8	33
3000	0.129	47.3	98
5000	0.216	78.8	164
10 000	0.432	157.5	328
20 000	0.863	315.1	656

The lamp-night figures assume that all recovered energy reaches the lamp after storage; battery round-trip losses, which were not included in η_{tot}, would reduce them.

G. Sensitivity Analysis

Fig. 5 shows the one-at-a-time sensitivity of the daily energy at 5000 vehicles per day, whose baseline is 0.216 kWh/day. The plate stroke has the largest effect (0.144–0.288 kWh/day for 10–20 mm), followed by the truck share (0.176 kWh/day with no trucks and 0.275 kWh/day with 5% trucks, the car share being reduced accordingly) and the utilisation factor λ (0.162–0.243 kWh/day for 0.60–0.90). Among the efficiencies, the generator (0.178–0.234 kWh/day for 0.70–0.92) matters more than the transmission (0.190–0.241 kWh/day for 0.75–0.95) and the power electronics (0.192–0.228 kWh/day for 0.80–0.95).

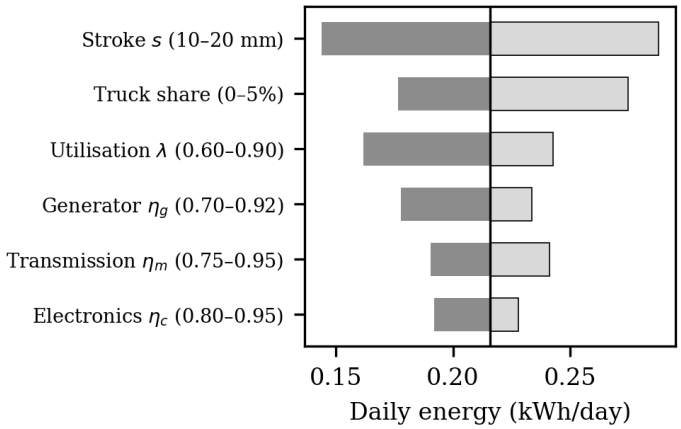


Fig. 5. One-at-a-time sensitivity of the daily energy at 5000 vehicles per day. Dark bars: parameter at its lower limit; light bars: upper limit. The vertical line is the baseline (0.216 kWh/day).

H. Comparison with Published Harvesters

Table III lists the outputs reported in retained studies that provide quantitative device output. Pavement-embedded piezoelectric devices reported outputs from microwatts per transducer in the field [11] to 84.3 mW for a stack device under a 10 kN, 10 Hz laboratory load [3]. The field monthly figure of [11] corresponds to about 180 J per month, or about 0.004 J per vehicle at 1500 vehicles per day, against 114.8 J per passenger car from the present model. Electromagnetic devices reached 171.14 mW [13] and 182 mW [21] in laboratory tests, and in a hybrid, harvester tested under the same excitation, the electromagnetic unit delivered 87.1 mW, compared with 63 µW for the triboelectric unit [22]. The thermoelectric cement composite of [9] produced 0.002 µW.

Table III. Reported Outputs of Road, Wind and Vehicle Harvesters

Device, placement [ref.]	Reported output (conditions)	Field test
Piezoelectric stack, pavement [3]	84.3 mW (10 kN, 10 Hz, 275 kΩ); 190 V open circuit under tire load	Yes
Piezoelectric cantilever array, pavement [11]	55.6 µW peak per transducer; ≈50 mWh/month for 16 units at 1500 veh/day	Yes
Stacked PZT + TEG, road [12]	0.25% of vehicle mechanical power reached harvester; PZT efficiency 37%	Yes
Flexible piezo composite, roadside [8]	≈16 V peak-to-peak under a motorcycle	Yes

Device, placement [ref.]	Reported output (conditions)	Field test
Thermoelectric cement [9]	0.002 μW at ΔT = 19.1 K	No
Electromagnetic, up-frequency, pavement [13]	171.14 mW (9 Hz, 3.0 mm); no voltage decay after 100 000 cycles	No
Piezo–electromagnetic, rotary [21]	182 mW at 120 r/min	No
Piezo/EM/triboelectric hybrid [22]	EM 87.1 mW; piezo 26.17 mW; tribo 63 μW (4 Hz)	No
Tribo–EM wind turbine, urban [18]	Start-up at 1.2 m/s wind speed	No
PVDF patches on tire [17]	Voltage rose with patch size, speed and load	Yes
Regenerative suspension control [16]	+37.3% energy vs. regenerative damper (simulation)	No
This work, displacement EM	114.8 J per car (model, s = 15 mm)	No

IV. Discussion

A. Energy Yield Relative to Pavement Harvesters

The main result is that a displacement-type electromechanical harvester with a stroke of 10–20 mm can recover of the order of 10^2 J per passenger car, several orders of magnitude more than the per-vehicle yield implied by the field data of pavement-embedded piezoelectric devices (about 0.004 J per vehicle derived from [11]). The difference follows from (2): the available work is proportional to the stroke, and a plate that moves by 15 mm offers far more work than a pavement that deflects by fractions of a millimetre. The low vehicle-to-harvester fraction of 0.25% measured by Dipon *et al.* [12] has the same origin. Model and measurements are, however, not strictly comparable, because Table III mixes field and laboratory results and the present values have not yet been measured on a prototype.

B. Choice of Conversion Principle

The choice of electromagnetic conversion agrees with the published comparisons. Under identical excitation, the electromagnetic unit of the hybrid harvester in [22] produced more than 1000 times the power of the triboelectric unit, and electromagnetic pavement and rotary harvesters reached 171–182 mW in the laboratory [13], [21]. Triboelectric and polymer piezoelectric devices appear better suited to self-powered sensing, such as traffic and tyre–road contact monitoring [10], [17], than to supplying lighting loads.

C. Energy Cost to the Vehicle and Siting

The recovered energy is not free. According to (6), the harvester removes about 1% of the kinetic energy of a vehicle at 20 km/h, and on a free-flowing road this energy would be replaced by fuel or traction battery energy. The device is therefore appropriate where vehicles must slowdown in any case and where the corresponding energy would otherwise be dissipated in brakes: pedestrian crossings near schools, entrances to parking areas, toll and checkpoint approaches, and industrial or residential access roads where speed bumps are already installed. At such sites, the plate can replace a conventional speed bump. This sitting argument is qualitative; a net energy balance at a specific site would require measured speed profiles with and without the device.

D. Design Requirements

The kinematic results set the main design requirements. Pulses of about 1 kW lasting about 50 ms require a generator and converter rated for the peak rather than the mean power, and a flywheel or electrical buffer to spread the energy over the idle intervals. The number of load cycles is high: at 5000 vehicles per day with two axles each, the plate completes about 10 000 strokes per day, or about 3.7 million per year. The 100 000-cycle endurance tests reported for an electromagnetic [13] and a piezoelectric [3] pavement harvester correspond to about ten days of such traffic, so gear, clutch and spring fatigue over millions of cycles is the main durability question for the proposed device.

The torque results show that the two design limits are set by different vehicles. Heavy trucks set the strength requirements: the overrunning clutch, the pinion and the rack must carry about 520 N·m at the pinion, nine times the passenger-car value. Passenger cars, which make up most of the traffic, set the efficiency requirements: the generator works most of the time at about 2.5 N·m, and its efficiency at this partial load, not at rated load, determines η_g. A torque limiter or a slipping clutch that caps the transmitted torque would allow a smaller gear train while sacrificing part of the truck energy, which in the baseline mix is about 20% of the total. The flywheel required by (8) is small, about 0.75 kg, so the buffering between axles adds little mass or cost; the battery, of the order of 50 A·h for one lamp-night, is the larger storage component.

Because the raised plate acts as a speed bump, its profile, marking, and installation must also satisfy the road authority rules for traffic-calming devices. The stroke is a compromise between energy, which grows linearly with s according to (3), and driver comfort and vehicle clearance, which limit the height of the plate above the road.

E. Relation to Other Energy Sources

On-vehicle harvesting through regenerative suspensions [14]–[16] recovers energy that would otherwise be dissipated in dampers, but the energy then serves the vehicle, not the road-side loads considered here. Roadside wind harvesters [18], [19] use a different source and could be combined with the proposed device in a hybrid supply for lighting or signals at the same site.

Table V summarises the approaches discussed in this section by the scale of their output, the energy they take from the vehicle and the application for which the evidence supports them.

Table V. Qualitative Comparison of Approaches for Road-Side Loads

Approach [refs.]	Output scale	Energy taken from vehicle	Supported use
Pavement piezoelectric [3], [11], [12]	µW–mW; ≈4 mJ per vehicle in field [11]	Negligible	Self-powered traffic sensing
Displacement electromagnetic (this work)	≈10^2 J per car (model)	≈1% of kinetic energy at 20 km/h	Lighting and signs at calming sites
Triboelectric, polymer piezo [10], [22], [17]	µW level per unit [22]	Negligible	Sensing, monitoring
Thermoelectric pavement [9]	0.002 µW per sample [9]	None	Not yet practical
Roadside wind [18], [19]	Depending on wind speed	None	Lights, sensors
Regenerative suspension [14]–[16]	on board (simulated gains [16])	Returned to vehicle	Vehicle electrical system

F. Limitations and Validation Protocol

The study has four limitations. First, the efficiencies in Table I are assumptions; the sensitivity band of Fig. 3 shows their effect, but the actual η_{tot} must be measured. Second, the model uses static loads and neglects dynamic amplification, speed-dependent generator losses and lateral wheel wander, which reduces the share of wheels that fully load a plate narrower than the lane. Third, the literature search covered PubMed only, which indexes part of the engineering literature; databases such as IEEE Xplore and Scopus were not searched. Fourth, no prototype results are yet available.

A validation protocol follows directly from the model. On a servo-hydraulic load frame, the plate should be driven through strokes of 10, 15 and 20 mm under peak loads of about 7, 17 and 65 kN, which correspond to the axle loads of the three vehicle classes, at stroke times of 0.04–0.11 s, which correspond to 10–30 km/h over a 0.30 m plate. For each case the electrical energy delivered to a set of resistive loads and to the battery should be integrated over the stroke and divided by the measured mechanical work to obtain η_{tot} and λ. A fatigue test of at least several million strokes would then check the transmission and the clutch. Finally, a field installation at a traffic-calming site with an automatic vehicle counter and speed measurement would allow the measured daily energy to be compared with (4), and the change in approach speed to be recorded.

V. Conclusion

A traffic-actuated electromechanical road harvester (Patent IAP 8475) was described, and a closed-form model of the energy it recovers, $E_{el} = \eta_{tot} mgs$, was derived. With an assumed overall efficiency of 0.52 and a 15 mm stroke, the model predicts about 115 J per passenger car, 268 J per light commercial vehicle and 1.53 kJ per heavy truck, and about 0.22 kWh/day for 5000 vehicles per day; about 11 100 vehicles per day would supply one 40 W LED lamp for 12 h. These per-vehicle values exceed those implied by field data from pavement-embedded piezoelectric harvesters by several orders of magnitude. Because the device removes about 1% of the kinetic energy of a vehicle at 20 km/h, it should be installed where traffic calming is already required. Prototype measurement of conversion efficiency and long-term fatigue testing are needed before these estimates can be confirmed.

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SCIENCE FOR A SUSTAINABLE CENTRAL ASIA

Влияние знания иностранных языков на уровень зарплаты в Узбекистане

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Аннотация

Статья посвящена анализу влияния владения иностранными языками на уровень заработной платы в Узбекистане. На основе эмпирических исследований рассматривается связь между знанием второго (преимущественно английского) языка и доходом специалистов, а также анализируются современные реформы в системе образования и их роль в формировании человеческого капитала.

Ключевые слова: иностранные языки, английский язык, заработная плата, Узбекистан, человеческий капитал, языковая политика, экономика языка.

Annotatsiya

Maqola O‘zbekistonda chet tillarini bilishning ish haqi darajasiga ta’sirini tahlil qilishga bag‘ishlangan. Empirik tadqiqotlar asosida ikkinchi (asosan ingliz) tilini bilish va mutaxassislar daromadi o‘rtasidagi bog‘liqlik ko‘rib chiqiladi, shuningdek, ta’lim tizimidagi zamonaviy islohotlar va ularning inson kapitalini shakllantirishdagi roli tahlil qilinadi.

Kalit so‘zlar: xorijiy tillar, ingliz tili, ish haqi, O‘zbekiston, inson kapitali, til siyosati, til iqtisodiyoti.

Annotation

The article is dedicated to analyzing the impact of foreign language proficiency on wage levels in Uzbekistan. Based on empirical research, it examines the relationship between second language (primarily English) skills and specialist income, as well as analyzing current education system reforms and their role in human capital formation.

Keywords: foreign languages, English language, wages, Uzbekistan, human capital, language policy, economics of language.

Введение

Современный Узбекистан активно интегрируется в мировое экономическое и образовательное пространство. В этих условиях знание иностранных языков, особенно английского, становится не просто преимуществом, а важным фактором конкурентоспособности на рынке труда. Государство, осознавая это, с 2012 года проводит масштабные реформы, внедряя непрерывное обучение иностранным языкам, начиная со школьной скамьи. [1] Однако насколько изучение языка конвертируется в реальный рост доходов? Ответ на этот вопрос это ключ к пониманию эффективности текущей образовательной политики и личных стратегий профессионального роста.

Основная часть

Недавние исследования узбекских экономистов дают вполне конкретный ответ на вопрос о финансовой отдаче от знания языков. Согласно данным научной работы, опубликованной в 2025 году, знание второго языка, а именно английского, увеличивает заработок в среднем на 10–20%. Оценка охватывает работников всех сфер деятельности, а не отдельные профессиональные группы. [2] При этом наиболее высокая «премия» за знание языка наблюдается в экономически активных регионах, где выше конкуренция и больше возможностей для международного взаимодействия. [2] Интересно, что исследование также показывает: знание английского языка как второго дает более высокую прибавку к доходу (в среднем 16,3%), чем, например, владение русским языком. [2] Это отражает глобальный тренд, где английский является основным языком бизнеса, науки и современных технологий. В то же время, владение государственным узбекским языком как родным не обеспечивает такого же экономического преимущества, что, вероятно, связано с его доминирующим положением в повседневной коммуникации, а не в сферах с высокой добавленной стоимостью.

Самый высокий рост зарплат в Узбекистане в последние годы наблюдается в таких сферах, как информация и связь (IT), операции с недвижимостью и финансы. [3] Именно здесь требуются специалисты, способные работать с международными стандартами, зарубежными контрагентами и передовыми технологиями, что немыслимо без хорошего английского языка.

Однако путь к высокооплачиваемой работе через язык сопряжен с рядом вызовов. Во-первых, по данным индекса EF English Proficiency Index за 2024 год, Узбекистан занимает 98-е место из 116 стран, что указывает на «очень низкий уровень» владения языком. [4] Это говорит о системной проблеме: массовое изучение языка в школах пока не дает желаемого результата. В 2021 году — из почти 53 тысяч учителей иностранного языка лишь чуть более 4% имели международный или национальный сертификат, подтверждающий высокий уровень. [5] К началу 2025 года этот показатель среди учителей превысил 56,5% (около 28 тысяч человек получили документы уровня B2 и выше). [6] При этом учителя с высоким уровнем языка (C1) часто предпочитают уходить в частные образовательные центры из-за более высокой оплаты труда, что создает дисбаланс в системе.

Заключение

Таким образом, данные исследований однозначно подтверждают положительное влияние владения английским языком на уровень заработной платы в Узбекистане. Языковой навык становится реальным экономическим активом, позволяющим специалистам претендовать на более высокооплачиваемые позиции в развивающихся секторах экономики. Для молодежи это означает, что инвестиции в изучение языка — это прямой вклад в свое будущее благосостояние. Однако для того чтобы это преимущество стало доступно широким массам, необходимы дальнейшие реформы в системе образования, направленные на повышение качества преподавания и создание мотивации для учителей оставаться в профессии.

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Tibbiyot muassasalarida texnika xavfsizligini ta’minlashning zamonaviy yondashuvlari: muammolar, xavflarni baholash va profilaktika choralari

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Annotatsiya

Mazkur maqolada tibbiyot muassasalarida texnika xavfsizligini ta’minlashning zamonaviy nazariy va amaliy masalalari kompleks tahlil qilingan. Tibbiy tashkilotlarda xodimlar faoliyati elektr qurilmalari, tibbiy apparatura, mexanik uskunalar, bosim ostidagi tizimlar, kriogen vositalar, yong‘in xavfi, ionlashtiruvchi va ionlashtirmaydigan nurlanish manbalari, kimyoviy moddalar hamda boshqa xavfli ishlab chiqarish omillari bilan bog‘liq bo‘lishi mumkin. Shu sababli texnika xavfsizligi faqat individual himoya vositalaridan foydalanish bilan cheklanmasdan, xavflarni oldindan aniqlash, risklarni baholash, muhandislik nazorati, texnik xizmat ko‘rsatish, xodimlarni o‘qitish, favqulodda vaziyatlarga tayyorgarlik va xavfsizlik madaniyatini shakllantirishni o‘z ichiga oluvchi kompleks boshqaruv tizimi sifatida qaralishi lozim.

Tadqiqotning metodologik asosini O‘zbekiston Respublikasining mehnatni muhofaza qilish, sanitariya-epidemiologik osoyishtalik, elektr xavfsizligi va yong‘in xavfsizligiga oid normativ-huquqiy hujjatlari, shuningdek Jahon sog‘liqni saqlash tashkiloti va Xalqaro mehnat tashkilotining tibbiyot xodimlari xavfsizligi bo‘yicha tavsiyalarining tahlili tashkil etdi. Tahlil natijasida tibbiyot muassasalarida texnika xavfsizligini boshqarishning asosiy elementlari: xavflarni identifikatsiya qilish, risklarni matritsali baholash, muhandislik va tashkiliy nazorat, texnik qurilmalarni rejali profilaktik tekshirish, xodimlarni kompetensiyaga asoslangan o‘qitish va hodisalarni tahlil qilishdan iborat ekani aniqlandi.

Maqolada tibbiy muassasalarda texnika xavfsizligini takomillashtirish uchun “xavfni aniqlash – riskni baholash – nazorat chorasi – monitoring – qayta baholash” sikliga asoslangan model taklif etiladi.

Kalit so‘zlar: texnika xavfsizligi, tibbiyot muassasasi, mehnat xavfsizligi, kasbiy xavf, risk, elektr xavfsizligi, tibbiy uskunalar, yong‘in xavfsizligi, radiatsion xavfsizlik, xavfsizlik madaniyati.

MODERN APPROACHES TO ENSURING TECHNICAL SAFETY IN HEALTHCARE FACILITIES: PROBLEMS, RISK ASSESSMENT AND PREVENTIVE MEASURES

Abstract

This article provides a comprehensive analysis of modern approaches to ensuring technical safety in healthcare facilities. Healthcare workers may be exposed to electrical equipment, medical devices, mechanical systems, pressurized systems, cryogenic equipment, fire hazards, ionizing and non-ionizing radiation, hazardous chemicals and other occupational hazards. Therefore, technical safety should not be limited to the use of personal protective equipment but should be considered as an integrated management system based on hazard identification, risk assessment, engineering controls, preventive maintenance, personnel training, emergency preparedness and development of a safety culture.

The methodological basis of the study consisted of an analysis of the regulatory framework of the Republic of Uzbekistan concerning occupational safety, sanitary and epidemiological well-being, electrical safety and fire safety, together with recommendations of the World Health Organization and the International Labour Organization concerning health-worker safety. The analysis demonstrates that effective technical safety management in healthcare facilities should include hazard identification, risk assessment, engineering and administrative controls, preventive maintenance of technical equipment, competency-based training and incident analysis.

A technical safety management model based on the cycle “hazard identification – risk assessment – control measures – monitoring – reassessment” is proposed.

Keywords: technical safety, healthcare facilities, occupational safety, occupational hazards, risk assessment, electrical safety, medical equipment, fire safety, radiation safety, safety culture.

СОВРЕМЕННЫЕ ПОДХОДЫ К ОБЕСПЕЧЕНИЮ ТЕХНИЧЕСКОЙ БЕЗОПАСНОСТИ В МЕДИЦИНСКИХ УЧРЕЖДЕНИЯХ: ПРОБЛЕМЫ, ОЦЕНКА РИСКОВ И ПРОФИЛАКТИКА

Аннотация

В статье представлен комплексный анализ современных подходов к обеспечению технической безопасности в медицинских учреждениях. Деятельность медицинских работников связана с эксплуатацией электрического и медицинского оборудования, механических устройств, систем под давлением, источников излучения, химических веществ, систем кислородоснабжения и других потенциально опасных факторов. В связи с этим техническая безопасность должна рассматриваться как интегрированная система управления рисками, включающая идентификацию опасностей, оценку профессиональных рисков, инженерные и организационные меры контроля, профилактическое техническое обслуживание, обучение персонала и формирование культуры безопасности.

На основе анализа национальных нормативных документов Республики Узбекистан и международных рекомендаций ВОЗ и МОТ предложена модель управления технической безопасностью в медицинских организациях.

Ключевые слова: техническая безопасность, медицинские учреждения, профессиональная безопасность, риск, медицинское оборудование, электрическая безопасность, пожарная безопасность, радиационная безопасность, культура безопасности.

1. Kirish

Tibbiyot muassasalari zamonaviy diagnostika, davolash, reabilitatsiya va profilaktika texnologiyalarining jadal rivojlanishi bilan tavsiflanadi. Bugungi shifoxona oddiy davolash maskani emas, balki murakkab muhandislik infratuzilmasiga ega bo‘lgan ko‘p funksional tizimdir. Unda elektr ta’minoti, kislorod va boshqa tibbiy gazlar, ventilyatsiya, isitish va sovutish tizimlari, liftlar, sterilizatsiya uskunalari, laboratoriya qurilmalari, rentgen va boshqa diagnostika apparatlari, operatsion texnologiyalar, axborot-kommunikatsiya tizimlari hamda ko‘plab boshqa texnik vositalar uzluksiz ishlaydi.

Shu sababli tibbiyot muassasalaridagi xavfsizlik masalasi faqat bemor xavfsizligi bilan cheklanmaydi. Tibbiyot xodimining xavfsizligi ham tibbiy yordam sifatining muhim tarkibiy qismidir. Jahon sog‘liqni saqlash tashkiloti ma’lumotlariga ko‘ra, sog‘liqni saqlash sektorida biologik, kimyoviy, fizik, ergonomik va psixosotsial xavflar bilan bir qatorda elektr toki urishi, yiqilish, yong‘in, portlash va transport hodisalari kabi texnik xavflar ham mavjud. WHO va ILO tomonidan ishlab chiqilgan tibbiyot xodimlari mehnat xavfsizligi bo‘yicha qo‘llanmalarda mehnatni muhofaza qilish dasturlari nafaqat kasbiy jarohatlanish va kasalliklarni oldini olish, balki tibbiy yordamning sifati va xavfsizligini yaxshilashga xizmat qilishi ta’kidlangan. O‘zbekistonda tibbiyot muassasalarida xavfsiz mehnat sharoitlarini yaratish mehnatni muhofaza qilish, sanitariya-epidemiologik osoyishtalik, elektr energetikasi, yong‘in xavfsizligi va texnik jihatdan tartibga solish sohasidagi normativ-huquqiy talablar bilan bog‘liq.

Xususan, O‘zbekiston Respublikasining 2016-yil 22-sentabrdagi O‘RQ-410-son “Mehnatni muhofaza qilish to‘g‘risida”gi Qonuni mehnat xavfsizligini ta’minlashning tashkiliy, texnik, sanitariya-gigiyenik va profilaktik asoslarini belgilaydi

Tibbiyot muassasalarida xavfsizlikka qo‘yiladigan talablarning dolzarbligi 2026-yilda ham ortib bormoqda. Jumladan, ish joylaridagi shovqin, tebranish, infratovush va ultratovush darajalariga oid yangi 0111-26-son SanQvaN 2026-yilda tasdiqlangan. Bu mehnat muhitining fizik omillarini monitoring qilish va ularni nazorat qilishga bo‘lgan talablar takomillashayotganini ko‘rsatadi.

Shuningdek, yong‘in xavfsizligini ta’minlash va yong‘in o‘chirish vositalariga qo‘yiladigan umumiy texnik reglament O‘zbekiston Respublikasi Vazirlar Mahkamasining 2022-yil 28-sentabrdagi 536-son qarori bilan

tasdiqlangan. Elektr qurilmalaridan xavfsiz foydalanish masalalari esa Vazirlar Mahkamasining 2020-yil 11-noyabrdagi 712-son qarori bilan tasdiqlangan tegishli qoidalar bilan tartibga solinadi. Demak, tibbiyot muassasalarida texnika xavfsizligini ta’minlash ko‘p komponentli va tizimli yondashuvni talab qiladi.

Tadqiqotning maqsadi

Tadqiqotning maqsadi tibbiyot muassasalarida texnika xavfsizligini ta’minlashning zamonaviy holatini tahlil qilish, asosiy texnik xavflarni tizimlashtirish, ularni boshqarishning samarali mexanizmlarini aniqlash va tibbiyot tashkilotlari uchun amaliy xavfsizlik modelini ishlab chiqishdan iborat.

Tadqiqot vazifalari:

1. Tibbiyot muassasalarida uchraydigan asosiy texnik xavflarni tasniflash.
2. Elektr, mexanik, yong‘in, radiatsion va boshqa xavflarning xodimlarga ta’sirini tahlil qilish.
3. Texnik xavflarni boshqarishning mavjud yondashuvlarini o‘rganish.
4. Xavflarni baholash va nazorat qilish algoritmini ishlab chiqish.
5. Tibbiyot muassasalarida texnika xavfsizligini takomillashtirish bo‘yicha amaliy tavsiyalar ishlab chiqish.

Tadqiqot obyekti

Tibbiyot muassasalarining texnik va ishlab chiqarish muhiti.

Tadqiqot predmeti

Tibbiyot muassasalarida texnik xavflarni aniqlash, baholash, nazorat qilish va profilaktika qilish jarayonlari.

2. Material va metodlar

2.1. Tadqiqot dizayni

Mazkur tadqiqot **nazariy-tahliliy va tavsifiy tadqiqot** sifatida tashkil etildi.

Tadqiqot davomida quyidagi metodlardan foydalanildi:

- normativ-huquqiy hujjatlarni tahlil qilish;
- ilmiy adabiyotlarni kontent-tahlil qilish;
- xavflarni tasniflash;
- risklarni matritsali baholash;
- tizimli tahlil;
- qiyosiy tahlil;
- ekspert-amaliy yondashuv;
- “xavf manbai – hodisa – oqibat – nazorat chorasi” modeli.

Tadqiqotda mavjud hujjatlar va xalqaro tavsiyalar asosida tibbiyot muassasalarining texnik xavfsizligi uchun konseptual model ishlab chiqildi.

2.2. Axborot manbalari

Tahlil uchun quyidagi manbalar tanlandi:

- O‘zbekiston Respublikasining mehnatni muhofaza qilishga oid qonunchiligi;
- sanitariya-epidemiologik xavfsizlik bo‘yicha normativlar;
- elektr xavfsizligi bo‘yicha amaldagi qoidalar;
- yong‘in xavfsizligi bo‘yicha texnik reglamentlar;
- WHO va ILO tavsiyalari;
- ISO 45001 konsepsiyasi;
- tibbiyot xodimlari xavfsizligi bo‘yicha xalqaro qo‘llanmalar.

WHO ma’lumotlarida tibbiyot xodimlari uchun asosiy xavflar qatorida kasbiy infeksiyalar, bemorni noto‘g‘ri ko‘tarish, kimyoviy moddalar, radiatsiya, psixosotsial xavflar, zo‘ravonlik, shovqin, yiqilish, elektr toki urishi, portlash va yong‘in qayd etiladi

2.3. Riskni baholash modeli

Texnik xavfni baholash uchun quyidagi konseptual formula qo‘llanildi:

$$R = P \times S$$

bu yerda:

R – risk darajasi;

P – xavfli hodisaning yuz berish ehtimoli;

S – hodisa oqibatining og‘irligi.

Riskni quyidagicha tasniflash mumkin:

Risk darajasi	Qiymat	Tavsiya
Past	1–4	Mavjud nazoratni davom ettirish
O‘rta	5–9	Qo‘shimcha profilaktik choralar
Yuqori	10–16	Zudlik bilan nazorat choralarini kuchaytirish
Juda yuqori	17–25	Ishni to‘xtatish va xavfni bartaraf etish

Mazkur matritsa muassasaning ichki risk-baholash metodikasiga moslashtirilishi mumkin.

3. Natijalar

3.1. Tibbiyot muassasalaridagi texnik xavflarning asosiy guruhlari

Tahlil natijasida tibbiyot muassasalaridagi texnik xavflarni shartli ravishda quyidagi guruhlarga ajratish mumkin:

1. elektr xavflari;
2. mexanik xavflar;
3. yong‘in va portlash xavfi;
4. bosim ostidagi tizimlar xavfi;
5. tibbiy gazlar bilan bog‘liq xavflar;
6. radiatsion xavflar;
7. lazer va ultrabinafsha nurlanish;
8. issiqlik va sovuq ta’siri;
9. shovqin va tebranish;
10. texnik qurilmalar nosozligi;
11. ergonomik-texnik xavflar;
12. favqulodda elektr ta’minoti uzilishi;
13. avtomatlashtirilgan va raqamli tibbiy tizimlarning texnik xavflari.

1-jadval. Tibbiyot muassasalarida asosiy texnik xavflar

Xavf turi	Asosiy manba	Ehtimoliy oqibat
Elektr	Elektrokardiograf, defibrillyator, sterilizator, rozetkalar	Elektr toki urishi, kuyish
Mexanik	Lift, operatsion stol, laboratoriya uskunalari	Jarohatlanish
Yong‘in	Elektr tarmoqlari, kislorod, yonuvchan materiallar	Kuyish, zaharlanish
Radiatsion	Rentgen, KT, radioizotoplar	Nurlanish
Bosim	Kislorod ballonlari, kompressorlar	Portlash, jarohat
Termik	Sterilizator, autoklav	Kuyish
Shovqin	Kompressor, ventilyator, generator	Eshitish va stress muammolari
Tebranish	Ayrim texnik qurilmalar	Charchoq, funksional buzilish
Ergonomik	Noto‘g‘ri ish joyi, uskunaning joylashuvi	Mushak-skelet shikastlanishlari
Texnik nosozlik	Eskirgan uskunalar	Avariya, xizmatning to‘xtashi

3.2. Elektr xavfsizligi

Tibbiyot muassasalarida elektr energiyasi uzluksiz tibbiy faoliyat uchun zarur. Shu bilan birga elektr tizimi eng muhim texnik xavf manbalaridan biridir.

Elektr xavfining asosiy sabablari:

- izolyatsiyaning shikastlanishi;
- yerga ulash tizimining nosozligi;

- ortiqcha yuklama;
- sifatsiz elektr ulanishlari;
- nam muhit;
- nosoz elektr jihozlari;
- uzaytirgichlardan noto‘g‘ri foydalanish;
- texnik xizmat ko‘rsatishning kechiktirilishi.

Tibbiyot muassasasida elektr xavfsizligining o‘ziga xosligi shundaki, bemor organizmi ayrim muolajalar vaqtida elektr qurilmalariga juda yaqin bo‘ladi. Shu sababli elektr xavfsizligi xodim xavfsizligi bilan bir qatorda bemor xavfsizligining ham tarkibiy qismidir.

Elektr qurilmalarini texnik ekspluatatsiya qilish bo‘yicha O‘zbekiston Respublikasida amaldagi qoidalar elektr qurilmalarini ishonchli va xavfsiz ishlatishga qaratilgan.

Profilaktika choralari

- elektr qurilmalarini reja asosida texnik ko‘rikdan o‘tkazish;
- nosoz apparatlarni ishlatishni taqiqlash;
- yerga ulash tizimini nazorat qilish;
- nam qo‘l bilan elektr qurilmalariga tegmaslik;
- elektr taqsimlash shkaflarini begona shaxslar uchun yopiq saqlash;
- elektr tarmoqlariga ortiqcha yuklama bermaslik;
- xodimlarni elektr xavfsizligi bo‘yicha o‘qitish.

3.3. Tibbiy uskunalardan foydalanish xavfsizligi

Zamonaviy tibbiyotda apparatura diagnostika va davolashning ajralmas qismiga aylangan.

Bunga:

- defibrillyator;
- EKG apparati;
- sun’iy nafas oldirish apparati;
- infuzion nasos;
- elektroxirurgik qurilmalar;
- monitorlar;
- sterilizatorlar;
- autoklavlar;
- laboratoriya analizatorlari;
- rentgen apparatlari;
- kompyuter tomografiyasi;
- ultratovush apparatlari;
- lazer qurilmalari kiradi.

Har bir qurilmaning texnik pasporti, foydalanish yo‘riqnomasi, texnik xizmat ko‘rsatish jadvali va mas’ul shaxsi bo‘lishi kerak.

Asosiy tamoyil

“Uskunani bilmasdan ishlatish – xavfsizlikni buzishdir.”

Shu sababli xodim apparaturadan foydalanishdan oldin:

1. qurilmaning vazifasini;
2. ishlash prinsipini;
3. xavfsizlik talablarini;
4. favqulodda o‘chirish mexanizmini;
5. signal va indikatorlarni;
6. nosozlik yuz bergandagi harakatlarni bilishi kerak.

3.4. Mexanik xavfsizlik

Mexanik xavflar tibbiyot muassasalarida ko‘pincha yetarli baholanmaydi.

Ularning manbalari:

- liftlar;
- bemor ko‘tarish moslamalari;
- operatsion stollar;
- g‘ildirakli aravachalar;
- sterilizatsiya qurilmalari;
- laboratoriya sentrifugalari;
- ventilyatsiya agregatlari;
- texnik xizmat ko‘rsatish qurilmalari.

Mexanik xavfsizlikni ta’minlashda harakatlanuvchi qismlarni himoyalash, uskunaning texnik holatini tekshirish va ishlab chiqaruvchi ko‘rsatmalariga qat’iy rioya qilish muhimdir.

3.5. Avtoklav va sterilizatsiya uskunalaridan xavfsiz foydalanish

Sterilizatsiya bo‘limlari tibbiyot muassasalaridagi texnik xavfi yuqori hududlardan biridir.

Avtoklavlar:

- yuqori harorat;
- bug‘;
- yuqori bosim

bilan ishlaydi.

Shuning uchun quyidagi xavflar mavjud:

- termik kuyish;
- bosim ta’sirida jarohatlanish;
- bug‘dan kuyish;
- qurilma portlashi;
- elektr toki urishi.

Xavfsizlik choralari

Avtoklav bilan ishlashda:

- faqat maxsus o‘qitilgan xodim;
- texnik soz qurilma;
- himoya vositalari;
- ishga tushirishdan oldingi tekshiruv;
- bosimning tushganini tekshirish;
- ishlab chiqaruvchi yo‘riqnomasiga rioya qilish

majburiy elementlar bo‘lishi kerak.

3.6. Tibbiy gazlar va kislorod tizimlarining xavfsizligi

Tibbiyot muassasalarida kislorod hayotiy zarur resurs bo‘lishi bilan birga yong‘in xavfini keskin oshirishi mumkin.

Kislorodning o‘zi yonuvchi modda bo‘lmasa-da, u yonish jarayonini keskin kuchaytiradi.

Shuning uchun:

- kislorod ballonlarini to‘g‘ri saqlash;
- ularni issiqlik manbalaridan uzoqda joylashtirish;
- ballonlarni mexanik shikastlanishdan himoyalash;
- gaz tizimlarini muntazam tekshirish;
- moy va yog‘larning kislorod uskunalariga tushishiga yo‘l qo‘ymaslik;
- yong‘in xavfsizligi talablariga rioya qilish

zarur.

3.7. Yong‘in xavfsizligi

Tibbiyot muassasasida yong‘in xavfi boshqa obyektlarga qaraganda murakkabroq oqibatlarga olib kelishi mumkin.

Sababi:

- bemorlarning harakatlanishi cheklangan;
- intensiv terapiya bemorlarini tez evakuatsiya qilish qiyin;

- kislorod mavjud;
- elektr uskunalari ko‘p;
- ko‘plab yonuvchi materiallar mavjud;
- operatsion va reanimatsiya xonalarida maxsus texnologik jarayonlar mavjud.

O‘zbekistonda yong‘in xavfsizligini ta’minlashga oid umumiy texnik reglament Vazirlar Mahkamasining 2022-yil 28-sentabrdagi 536-son qarori bilan tasdiqlangan.

Tibbiyot muassasasida yong‘inning oldini olishning 5 darajasi

1. Oldini olish

Elektr va texnik nosozliklarni bartaraf etish.

2. Erta aniqlash

Yong‘in signalizatsiyasi.

3. Tezkor javob

O‘t o‘chirish vositalari.

4. Evakuatsiya

Bemorlar va xodimlarni xavfsiz hududga chiqarish.

5. Tibbiy yordam

Kuyish, tutundan zaharlanish va travmalarga yordam.

3.8. Radiatsion xavfsizlik

Rentgen, KT va boshqa ionlashtiruvchi nurlanish manbalaridan foydalanish tibbiy diagnostikaning muhim qismidir.

Radiatsion xavfsizlikning asosiy prinsipi:

ALARA — As Low As Reasonably Achievable, ya’ni nurlanishni oqilona erishish mumkin bo‘lgan eng past darajada saqlash.

WHO tibbiyot sektorida ionlashtiruvchi va ionlashtirmaydigan radiatsiya xodimlar uchun muhim kasbiy xavf ekanini qayd etadi.

Radiatsion xavfsizlikda:

- vaqtni kamaytirish;
- masofani oshirish;
- himoyalovchi ekranlardan foydalanish

asosiy tamoyillar hisoblanadi.

3.9. Shovqin va tebranish

Tibbiyot muassasalarida shovqin ko‘plab manbalardan kelib chiqishi mumkin:

- ventilyatsiya;
- kompressorlar;
- generatorlar;
- texnik agregatlar;
- laboratoriya qurilmalari;
- transport vositalari.

2026-yilda O‘zbekistonda ish joylaridagi shovqin, tebranish, infratovush va ultratovush bo‘yicha 0111-26-son SanQvaN tasdiqlangan. Bu fizik omillarni mehnat sharoitlarini baholashning dolzarb yo‘nalishlaridan biri ekanini ko‘rsatadi.

3.10. Texnik xavfsizlikda inson omili

Texnik qurilmalarning xavfsizligi faqat ularning konstruksiyasiga bog‘liq emas.

“Texnika + inson + muhit” uchligi xavfsizlikning asosiy tizimini tashkil etadi.

Nosozliklarning muhim qismi quyidagi insoniy omillar bilan bog‘liq bo‘lishi mumkin:

- yetarli tayyorgarlikning yo‘qligi;
- yo‘riqnomani bajarmaslik;
- charchoq;

- shoshilish;
- e’tiborsizlik;
- nazoratning sustligi;
- xavf haqida xabar bermaslik.

WHO sog‘liqni saqlash sektorida uzoq ish vaqti, smenali ish, vaqt bosimi va qo‘llab-quvvatlashning yetishmasligini ham xavf omillari sifatida ko‘rsatadi.Shu sababli texnika xavfsizligi xodimni “ayblash” emas, xavfli xatti-harakatlarning sabablarini aniqlashga asoslangan tizimga aylanishi kerak.

3.11. Texnika xavfsizligi bo‘yicha xodimlarni o‘qitish

Xodimning texnika xavfsizligi bo‘yicha bilimlari xavfsizlik tizimining asosiy komponentidir.

O‘qitish quyidagi bosqichlarni qamrab olishi mumkin:

1. kirish instruktaji;
2. ish joyidagi dastlabki instruktaj;
3. takroriy instruktaj;
4. rejadan tashqari instruktaj;
5. maqsadli instruktaj;
6. amaliy mashg‘ulot;
7. bilimlarni tekshirish.

Biroq zamonaviy yondashuvda faqat nazariy instruktaj yetarli emas.

Xodim:

“Bilaman” emas, **“amalda bajara olaman”**

darajasiga ega bo‘lishi kerak.

Shu sababli simulyatsiya asosidagi o‘qitish:

- elektr avariyasi;
- yong‘in;
- kislorod tizimidagi avariya;
- apparatura nosozligi;
- bemorni evakuatsiya qilish

kabi holatlarda samarali hisoblanadi.

3.12. Texnika xavfsizligini boshqarishning taklif etilayotgan modeli

Tadqiqot natijalariga asoslanib, tibbiyot muassasalari uchun quyidagi **5 bosqichli texnika xavfsizligi modeli** taklif etiladi.

1-bosqich. Xavfni aniqlash

Nima xavf tug‘dirishi mumkin?

2-bosqich. Riskni baholash

Qanchalik ehtimol va qanchalik og‘ir oqibat?

3-bosqich. Nazorat chorasi

Xavfni qanday kamaytiramiz?

↓4-bosqich. Monitoring

Chora haqiqatan ishlayaptimi?

5-bosqich. Qayta baholash

Yangi xavf paydo bo‘ldimi?

Bu jarayon uzluksiz sikl ko‘rinishida ishlashi kerak.

4. Muhokama

Olingan natijalar shuni ko‘rsatadiki, tibbiyot muassasalarida texnika xavfsizligini an’anaviy “qoidaga rioya qilish” modeli asosida tashkil etish yetarli emas.

Zamonaviy xavfsizlik konsepsiyasida asosiy e’tibor:

qoidabuzarlikni jazolashdan → xavfni oldindan boshqarishga

qaratilmoqda.

Xalqaro mehnat tashkiloti xavfsizlikni faqat qonunchilik talablarini bajarish bilan cheklamasdan, xavfsizlik madaniyati, risklarni boshqarish va xodimlarning jarayonga jalb etilishi bilan bog‘laydi. Xalqaro mehnat tashkiloti (ILO)ning 2024–2030-yillarga mo‘ljallangan global strategiyasida mehnat xavfsizligini rivojlantirishning asosiy yo‘nalishlari sifatida milliy xavfsizlik tizimlarini takomillashtirish, hamkorlik va investitsiyalarni kuchaytirish hamda tashkilotlarda mehnat xavfsizligini boshqarish tizimlarini rivojlantirish belgilangan.

Bu yondashuv tibbiyot muassasalariga ham to‘liq tatbiq etilishi mumkin.

4.1. Texnika xavfsizligi va bemor xavfsizligi o‘rtasidagi bog‘liqlik

Tibbiyot xodimi xavfsizligi va bemor xavfsizligini ikki alohida tizim sifatida ko‘rish metodologik jihatdan noto‘g‘ri.

Masalan:

Elektr tizimi nosozligi

→ apparatura ishlamaydi

→ davolash jarayoni buziladi

→ bemor xavfsizligi pasayadi.

Yoki:

Kislorod tizimidagi nosozlik

→ yong‘in xavfi

→ bemorlarni evakuatsiya qilish zarurati

→ tibbiy yordamning uzilishi.

Demak:

Tibbiyot xodimining xavfsizligi – bemor xavfsizligining institutsional shartidir.

Xalqaro sog‘liqni saqlash tashkiloti (WHO) ham sog‘liqni saqlash xodimlari xavfsizligini tibbiy yordamning sifati va xavfsizligi bilan bevosita bog‘laydi.

4.2. Muhandislik nazorati ustuvorligi

Xavfni nazorat qilishda individual himoya vositalari eng birinchi choraga aylantirilmasligi kerak.

Samarali yondashuv quyidagi ierarxiyaga asoslanadi:

1. xavfni yo‘q qilish;
2. xavfli texnologiyani xavfsizrog‘iga almashtirish;
3. muhandislik nazorati;
4. tashkiliy-ma’muriy nazorat;
5. individual himoya vositalari.

Masalan, elektr xavfi mavjud bo‘lsa, faqat rezina qo‘lqop berish bilan cheklanib qolish emas, balki:

- elektr tarmog‘ini texnik tekshirish;
- avtomatik himoya;
- yerga ulash;
- himoya qurilmalarini o‘rnatish

ustuvor bo‘lishi kerak.

4.3. Profilaktik texnik xizmatning ahamiyati

Tibbiyot uskunalarini faqat buzilgandan keyin ta’mirlash xavfsizlik nuqtayi nazaridan yetarli emas.

Reaktiv yondashuv:

buzildi → ta’mirlash.

Profilaktik yondashuv:

tekshirish → nosozlikni oldindan aniqlash → profilaktik ta’mirlash → qayta tekshirish.

Ikkinchi yondashuv tibbiyot muassasalarida xavfsizlikni sezilarli darajada oshirish imkonini beradi.

4.4. Raqamli texnologiyalar va texnik xavfsizlik

Raqamlashtirish tibbiyot muassasalarida xavfsizlikni monitoring qilish uchun yangi imkoniyatlar yaratadi.

Masalan:

- uskunaning texnik holatini elektron monitoring qilish;
- texnik xizmat muddatlarini avtomatik eslatish;
- elektr yuklamasini nazorat qilish;
- harorat va namlikni monitoring qilish;
- yong‘in signalizatsiyasini markazlashtirish;
- hodisalarni elektron ro‘yxatga olish.

Bunday tizimlar xavfsizlikni “hujjat yuritish”dan “real vaqt monitoringi”ga olib o‘tishi mumkin.

4.5. Iqlim o‘zgarishi va tibbiyot muassasalarining texnik xavfsizligi

Iqlim o‘zgarishi ham texnik xavfsizlik tizimiga yangi talablar qo‘ymoqda.

Juda yuqori harorat:

- elektr yuklamasini oshirishi;
- sovutish tizimlariga yuklamani kuchaytirishi;
- xodimlarda issiqlik stressini yuzaga keltirishi;
- ayrim tibbiy qurilmalarning ish rejimiga ta’sir qilishi mumkin.

ILO iqlim o‘zgarishi mehnat xavfsizligi uchun yangi va kuchayib borayotgan xavflarni yuzaga keltirayotganini ta’kidlaydi. Shuning uchun kelajakdagi tibbiyot muassasalarining texnik xavfsizlik tizimida iqlim xavflariga chidamlilik ham hisobga olinishi kerak.

5. Amaliy takliflar

Tibbiyot muassasalarida texnika xavfsizligini takomillashtirish uchun quyidagi tizimni joriy qilish maqsadga muvofiq.

1. “Texnik xavfsizlik pasporti”ni joriy etish

Har bir bo‘lim uchun:

- xavf manbalari;
- uskunalar;
- texnik xizmat muddati;
- mas’ul shaxs;
- favqulodda o‘chirish nuqtalari;
- evakuatsiya yo‘nalishlari

ko‘rsatiladi.

2. Har bir uskuna uchun xavfsizlik kartasi

Unda:

- qurilma nomi;
- inventar raqami;
- xavf turi;
- foydalanish qoidasi;
- taqiqlangan harakatlar;
- texnik xizmat sanasi;
- favqulodda holatda bajariladigan ishlar

ko‘rsatilishi kerak.

3. “Near miss” tizimini joriy qilish

Jarohat bilan tugamagan, ammo xavfli bo‘lgan hodisalar ham qayd etilishi kerak.

Masalan:

elektr kabelining qizib ketishi aniqlandi, lekin yong‘in sodir bo‘lmadi.

Bunday holat “hodisa bo‘lmadi” deb e’tiborsiz qoldirilmasligi kerak.

4. Har chorakda texnik xavfsizlik auditi

Auditda:

- elektr;
- yong‘in;
- tibbiy gaz;
- uskunalar;
- evakuatsiya;
- himoya vositalari

tekshirilishi kerak.

5. Amaliy simulyatsiyalar

Kamida yiliga bir necha marta:

- yong‘in;
- elektr avariyasi;
- kislorod sizib chiqishi;
- apparatura nosozligi;
- favqulodda evakuatsiya

bo‘yicha mashg‘ulotlar o‘tkazilishi lozim.

6. Tibbiyot muassasasida texnika xavfsizligini baholash uchun taklif etilgan indikatorlar

2-jadval. Xavfsizlik samaradorligini baholash ko‘rsatkichlari

Ko‘rsatkich	Baholash mezoni
Texnik ko‘rik	O‘z vaqtida bajarilishi
Xodimlar o‘qitilishi	100% qamrov
Elektr xavfsizligi	Rejali tekshiruvlar
Yong‘in xavfsizligi	Signalizatsiya va vositalar tayyorligi
Uskuna nosozligi	Qayd etilgan va bartaraf etilgan holatlar
Near-miss	Xabar berish faolligi
Favqulodda mashg‘ulot	O‘tkazilganligi
Evakuatsiya	Belgilangan vaqt ichida
Himoya vositalari	Mavjudligi va to‘g‘ri qo‘llanishi
Xavfsizlik auditi	Reja asosida bajarilishi

Muhim jihat shundaki, “near-miss” hodisalarining ko‘payishi har doim xavfsizlikning yomonlashganini anglatmaydi. Aksincha, xodimlarning xavf haqida ochiq xabar berish madaniyati shakllanayotganidan dalolat berishi mumkin.

7. Ilmiy yangilik

Tadqiqotning ilmiy yangiligi quyidagilardan iborat:

1. Tibbiyot muassasalaridagi texnika xavflari yagona tizimli tasnif asosida guruhlashtirildi.
2. Texnik xavfsizlik bemor xavfsizligi va xodim xavfsizligining integratsiyalashgan komponenti sifatida asoslandi.
3. Tibbiyot muassasalariga moslashtirilgan **“aniqlash – baholash – nazorat – monitoring – qayta baholash”** modeli taklif qilindi.
4. Texnik xavfsizlikni ta’minlashda profilaktik texnik xizmat va muhandislik nazoratining ustuvorligi asoslandi.
5. Xodimlarning texnik xavfsizlik kompetensiyasini faqat nazariy bilim emas, balki amaliy bajarish qobiliyati orqali baholash taklif qilindi.
6. “Near-miss” hodisalarini tibbiyot muassasalarida xavfsizlik monitoringining muhim indikatori sifatida qo‘llash taklif qilindi.

8. Amaliy ahamiyati

Tadqiqot natijalari:

- shifoxonalar;
- poliklinikalar;
- diagnostika markazlari;
- laboratoriyalar;
- tez tibbiy yordam tashkilotlari;
- tibbiyot oliy ta’lim muassasalari;
- klinik bazalar

faoliyatida foydalanilishi mumkin.

Taklif etilgan model asosida muassasaning texnika xavfsizligi bo‘yicha:

- ichki audit;
- xavflar reyestri;
- texnik xavfsizlik kartalari;
- xodimlarni o‘qitish dasturlari;
- simulyatsion mashg‘ulotlar;
- favqulodda vaziyatlar rejasi

ishlab chiqilishi mumkin.

9. Tadqiqotning cheklovlari

Mazkur tadqiqotning asosiy cheklovi uning nazariy-tahliliy xarakterga ega ekanligidir. Tadqiqotda muayyan tibbiyot muassasalaridagi real baxtsiz hodisalar statistikasi yoki ko‘p markazli epidemiologik ma’lumotlar asosida miqdoriy tahlil amalga oshirilmagan.

Shu sababli kelgusidagi tadqiqotlarda:

- tibbiyot muassasalaridagi texnik hodisalar statistikasi;
- xodimlarning xavfsizlik kompetensiyasi;
- xavfsizlik madaniyati;
- near-miss chastotasi;
- texnik xizmat ko‘rsatish sifati;
- xodimlarning o‘qitilish darajasi

bo‘yicha empirik ma’lumotlarni yig‘ish va statistik tahlil qilish maqsadga muvofiq.

10. Xulosa

Tibbiyot muassasalarida texnika xavfsizligi zamonaviy sog‘liqni saqlash tizimining muhim tarkibiy qismidir. Tibbiy texnologiyalarning murakkablashuvi bilan birga elektr, mexanik, radiatsion, yong‘in, termik, bosim, tibbiy gazlar, shovqin va boshqa texnik xavflarning turlari ham kengayib bormoqda.

Tahlil natijalari shuni ko‘rsatdiki, texnika xavfsizligini faqat xodimlarga yo‘riqnoma berish yoki individual himoya vositalari bilan ta’minlash yetarli emas. Samarali xavfsizlik tizimi xavfni oldindan aniqlash, riskni baholash, muhandislik nazorati, profilaktik texnik xizmat, xodimlarni kompetensiyaga asoslangan o‘qitish, favqulodda vaziyatlarga tayyorgarlik va xavfsizlik madaniyatini o‘z ichiga olishi kerak.

WHO va ILO yondashuvlari ham tibbiyot xodimlarining xavfsizligini alohida emas, balki sog‘liqni saqlash tizimining barqarorligi va tibbiy yordam sifati bilan bog‘liq kompleks masala sifatida ko‘radi.)

O‘zbekiston sharoitida esa texnika xavfsizligini tashkil etishda milliy mehnat va sanitariya qonunchiligi, elektr xavfsizligi qoidalari hamda yong‘in xavfsizligi bo‘yicha texnik reglamentlar talablarini bir-biri bilan integratsiyalash zarur.

Tadqiqot natijasida taklif etilgan **“xavfni aniqlash – riskni baholash – nazorat – monitoring – qayta baholash”** modeli tibbiyot muassasalarida texnik xavfsizlikni tizimli boshqarish uchun amaliy asos bo‘lib xizmat qilishi mumkin.

Eng muhim xulosa shundan iboratki:

Tibbiyot muassasasida texnika xavfsizligi – bu faqat texnik qurilmalarni himoya qilish emas, balki tibbiyot xodimi, bemor, texnologiya va muhit xavfsizligini yagona tizimda boshqarish jarayonidir.

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Bekobod shahri va Bekobod tumani hududlarida ichimlik suv olish inshootlarining holatini baholash

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Annotatsiya

Mazkur maqolada Bekobod shahri va Bekobod tumani hududlaridagi yer osti suvlarining gidrogeologik sharoitlari hamda mavjud ichimlik suv olish inshootlarining ekspluatatsion holati tahlil qilingan. Tadqiqotning asosiy maqsadi hududdagi suvli gorizontlarning shakllanish va tarqalish sharoitlarini, suv beruvchanlik xususiyatlarini, gidrogeokimyoviy tarkibini hamda ichimlik suv ta'minoti uchun foydalanish imkoniyatlarini baholashdan iborat. Tadqiqotlarda dala gidrogeologik kuzatuvlari, burg'ilash, tajriba-suv chiqarish ishlari, gidrogeologik monitoring, laboratoriya-gidrogeokimyoviy tahlillar, statistik va qiyosiy tahlil usullaridan foydalanilgan. Tadqiqot natijalariga ko'ra, hududdagi yer osti suvlarining shakllanishi geologik-litologik tuzilish, Sirdaryo vodiysi, sug'orish tizimlari va tog'oldi hududlaridan keluvchi yer osti oqimlari bilan chambarchas bog'liq. O'rta-quyi to'rtlamchi suvli gorizontlarda yuqori suv beruvchanlik va nisbatan past minerallashuv aniqlangan. Mazkur gorizontlarda minerallashuv asosan 0,2–0,5 g/l, ayrim neogen suvli gorizontlarda esa 0,46–0,61 g/l ni tashkil etadi. Yuqori to'rtlamchi grunt suvlarida ayrim hududlarda minerallashuv 1,6–1,8 g/l gacha yetishi aniqlangan. Tadqiqot natijalari Bekobod shahri va tumani ichimlik suv ta'minotini barqarorlashtirishda o'rta-quyi to'rtlamchi hamda chuqur joylashgan neogen suvli gorizontlardan foydalanish istiqbollarini ko'rsatadi. Shuningdek, 200–400 m chuqurlikdagi suvli gorizontlarni qo'shimcha o'rganish, yangi qidiruv-razvedka quduqlarini burg'ilash hamda yer osti suvlarining miqdoriy va sifat ko'rsatkichlari bo'yicha kompleks monitoring olib borish zarurligi asoslangan.

Kalit so'zlar: Bekobod, Dalverzin, yer osti suvlari, gidrogeologiya, suvli gorizont, VS-3 suv olish inshooti, ekspluatatsion zaxiralar, suv beruvchanlik, minerallashuv, umumiy qattiqlik, gidrogeokimyoviy tahlil, gidrogeologik monitoring.

ОЦЕНКА СОСТОЯНИЯ СООРУЖЕНИЙ ДЛЯ ЗАБОРА ПИТЬЕВОЙ ВОДЫ НА ТЕРРИТОРИИ ГОРОДА БЕКАБАДА И БЕКАБАДСКОГО РАЙОНА

Аннотация

В статье проанализированы гидрогеологические условия подземных вод на территории города Бекабад и Бекабадского района, а также эксплуатационное состояние существующих водозаборных сооружений питьевого назначения. Основной целью исследования является оценка условий формирования и распространения водоносных горизонтов, их водоотдачи, гидрогеохимического состава и возможностей использования подземных вод для питьевого водоснабжения. В работе использованы полевые гидрогеологические наблюдения, бурение, опытные откачки, гидрогеологический мониторинг, лабораторные гидрогеохимические анализы, статистический и сравнительный методы. Установлено, что формирование подземных вод связано с геолого-литологическим строением территории, долиной Сырдарьи, оросительной системой и подземным стоком со стороны предгорных районов. Средне-нижнечетвертичные водоносные горизонты характеризуются высокой водоотдачей и относительно низкой минерализацией. Их минерализация в основном составляет 0,2–0,5 г/л, а в отдельных неогеновых водоносных горизонтах — 0,46–0,61 г/л. В грунтовых водах верхнечетвертичных отложений на отдельных участках минерализация достигает 1,6–1,8 г/л. Полученные результаты показывают перспективность использования средне-нижнечетвертичных и глубокозалегающих неогеновых водоносных горизонтов для обеспечения питьевого водоснабжения Бекабада. Обоснована необходимость дополнительного изучения водоносных горизонтов на глубинах 200–400 м, бурения новых поисково-разведочных скважин и организации комплексного мониторинга количественных и качественных показателей подземных вод.

Ключевые слова: Бекабад, Дальверзин, подземные воды, гидрогеология, водоносный горизонт, водозаборное сооружение ВС-3, эксплуатационные запасы, водоотдача, минерализация, общая жесткость, гидрогеохимический анализ, гидрогеологический мониторинг.

ASSESSMENT OF THE CONDITION OF DRINKING WATER INTAKE FACILITIES IN THE CITY OF BEKABAD AND BEKABAD DISTRICT

Abstract

The article analyzes the hydrogeological conditions of groundwater in the city of Bekabad and Bekabad district, as well as the operational condition of existing drinking-water intake facilities. The main objective of the study is to assess the formation and distribution conditions of aquifers, their water-yielding capacity, hydrogeochemical composition, and the potential for using groundwater for drinking-water supply. The study employed field hydrogeological observations, drilling, test pumping, hydrogeological monitoring, laboratory hydrogeochemical analyses, and statistical and comparative methods. The results show that groundwater formation is closely related to the geological-lithological structure of the area, the Syr Darya valley, irrigation systems, and groundwater flow from the foothill areas. The Middle–Lower Quaternary aquifers are characterized by high water yield and relatively low mineralization. Their mineralization is mainly 0.2–0.5 g/L, while in some Neogene aquifers it is 0.46–0.61 g/L. In the groundwater of Upper Quaternary deposits, mineralization reaches 1.6–1.8 g/L in some areas. The results indicate the potential of the Middle–Lower Quaternary and deep Neogene aquifers for improving drinking-water supply in Bekabad. The study substantiates the need for further investigation of aquifers at depths of 200–400 m, drilling of new exploration wells, and comprehensive monitoring of the quantitative and qualitative characteristics of groundwater.

Keywords: Bekabad, Dalverzin, groundwater, hydrogeology, aquifer, VS-3 water intake facility, exploitable reserves, water yield, mineralization, total hardness, hydrogeochemical analysis, hydrogeological monitoring.

Kirish

Aholini sifatli va yetarli miqdordagi ichimlik suvi bilan ta’minlash hududlarning ijtimoiy-iqtisodiy rivojlanishida muhim omillardan biri hisoblanadi. Ayniqsa, suv resurslari cheklangan va mavjud yer usti hamda yer osti suvlarining gidrogeokimyoviy tarkibi o‘zgaruvchan bo‘lgan hududlarda ichimlik suv ta’minotining barqarorligini ta’minlash uchun istiqbolli yer osti suv manbalarini izlash, o‘rganish va ularning ekspluatatsion zaxiralarini ilmiy asosda baholash dolzarb masalalardan biridir.

Bekobod shahri va Bekobod tumani hududlarida aholi sonining ortishi, ichimlik suviga bo‘lgan talabning oshishi hamda mavjud suv olish inshootlarining ekspluatatsion holati yer osti suv resurslarini qayta o‘rganish va baholash zaruratini yuzaga keltirgan. Mazkur hududda ichimlik suvi ta’minotining asosiy manbalaridan biri bo‘lgan VS-3 suv olish inshootining ekspluatatsiya sharoitlari va yer osti suvlarining gidrogeologik hamda gidrogeokimyoviy ko‘rsatkichlari vaqt davomida sezilarli darajada o‘zgargan. Avvalgi gidrogeologik tadqiqotlar natijasida quyi–o‘rta to‘rtlamchi davr yotqiziqlaridagi suvli gorizontlarning ekspluatatsion zaxiralari A+B+C_1 toifalarida 156 ming m^3/kun miqdorida baholangan. Biroq Sirdaryo daryosi oqimining tartibga solinishi, suvning mineralizatsiyasi va qattiqligining ortishi, shuningdek, hududning gidrogeologik sharoitlariga antropogen ta’sirning kuchayishi natijasida yer osti suvlarining miqdoriy va sifat ko‘rsatkichlarini qayta baholash zarurati paydo bo‘lgan.2018–2019-yillarda olib borilgan gidrogeologik tadqiqotlar davomida VS-3 suv olish inshooti va unga tutash hududlarda yuqori neogen davriga mansub, katta chuqurliklarda joylashgan istiqbolli suvli gorizontlar aniqlangan. Tajriba-kuzatuv quduqlarida olib borilgan sinov suv chiqarish ishlari natijasida yuqori neogen va o‘rta to‘rtlamchi davr yotqiziqlaridagi suvli gorizontlarning suv beruvchanligi, pyezometrik sathi hamda gidrogeokimyoviy xususiyatlari aniqlangan. Olingan natijalar chuqur joylashgan suvli gorizontlardan Bekobod shahrining istiqbolli ichimlik suv ta’minotida foydalanish imkoniyatlari mavjudligini ko‘rsatgan. Shuningdek, 2019-yilda VS-3 suv olish inshooti hududida va unga tutash maydonlarda chuqurligi 380 m gacha bo‘lgan yangi ekspluatatsion quduqlarning burg‘ilanishi mavjud suv olish inshootining gidrogeologik sxemasini aniqlashtirish imkonini bergan. Yangi quduqlarning ishga tushirilishi natijasida yer osti suvlarining ekspluatatsion zaxiralarini qayta baholash, suvli gorizontlarning o‘zaro gidravlik bog‘liqligini aniqlash va suv olish inshootining istiqbolli ishlash sharoitlarini asoslash masalalari dolzarb ahamiyat kasb etgan. Bundan tashqari, Bekobod tumanidagi suv bilan yetarli darajada ta’minlanmagan qishloq aholi punktlarining aniqlanishi ushbu hududlar uchun qo‘shimcha ichimlik suvi manbalarini izlash va ularning gidrogeologik imkoniyatlarini baholashni talab etgan. 2020-yilda aniqlashtirilgan texnik topshiriqda Bekobod shahri uchun istiqbolli ichimlik suviga bo‘lgan ehtiyoj 15 ming

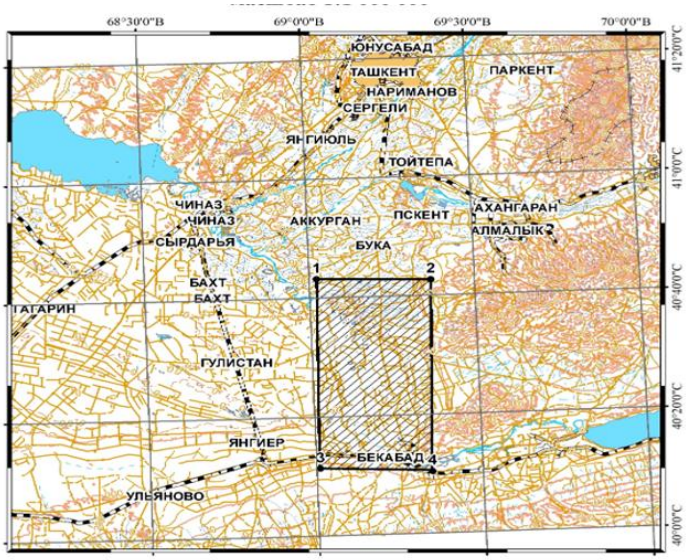
m³/kun, 13 ta qishloq aholi punkti uchun esa jami 10 ming m³/kun miqdorida belgilangan. Bu esa hududdagi yer osti suv resurslaridan oqilona va ilmiy asoslangan foydalanish masalasining dolzarbligini yanada oshiradi. Tadqiqot metodlari. Tadqiqot ishlari Bekobod tumani va Bekobod shahri hududida yer osti suvlarining tarqalish sharoitlari, suvli gorizontlarning gidrogeologik xususiyatlari, suv beruvchanligi va gidrogeokimyoviy tarkibini aniqlash hamda mavjud suv olish inshootlarining ekspluatatsion imkoniyatlarini baholashga yo‘naltirildi. Tadqiqotlarda dala gidrogeologik kuzatuvlari, burg‘ilash ishlari, tajriba-suv chiqarish, gidrogeologik monitoring va laboratoriya-gidrogeokimyoviy tahlil usullaridan foydalanildi. Tadqiqot hududining tabiiy-geografik va gidrogeologik sharoitlarini aniqlash maqsadida hududning geologik tuzilishi, relyefi, gidrografik tarmog‘i, yer usti va yer osti suvlarining o‘zaro bog‘liqligi hamda mavjud suv olish inshootlari o‘rganildi. Dala kuzatuvlari davomida quduqlarning joylashuvi, chuqurligi, suv sathi, suv chiqarish sharoitlari va suvli qatlamlarning litologik tarkibi qayd etildi. Hududning geologik kesimini aniqlash uchun burg‘ilash natijalari va quduqlardan olingan kern hamda shlam materiallarining litologik tavsifi amalga oshirildi. Suvli gorizontlarning yotish chuqurligi, qalinligi va tarqalish chegaralari aniqlanib, ularning gidrogeologik sharoitlari baholandi. Suvli gorizontlarning filtratsion va suv beruvchanlik xususiyatlarini aniqlash uchun tajriba-suv chiqarish ishlari olib borildi. Bunda quduqlardan ma’lum vaqt davomida suv chiqarilib, suv sarfi (Q), suv sathining pasayishi (S) va solishtirma suv sarfi (q) aniqlanadi. [1]

Solishtirma suv sarfi quyidagi ifoda orqali baholandi:

bu yerda: q - solishtirma suv sarfi l/s·m, Q - quduqdan olinayotgan suv sarfi, l/s, S - suv sathining pasayishi m.

Mazkur ko‘rsatkichlar asosida suvli gorizontlarning suv beruvchanligi va ekspluatatsiya qilish imkoniyatlari baholandi. Tajriba-suv chiqarish natijalari suv olish inshootlarining optimal ekspluatatsion rejimini aniqlash hamda istiqbolli quduqlarning suv sarfini baholashda qo‘llanildi. Yer osti suvlarining tabiiy va ekspluatatsion sharoitdagi o‘zgarishini aniqlash uchun kuzatuv quduqlarida suv sathi muntazam o‘lchandi. Pyezometrik suv sathining o‘zgarishi mavsumiylik, yog‘in-sochin, sug‘orish ishlari, Sirdaryo va kanallardagi suv rejimi hamda suv olish inshootlarining ekspluatatsion yuklamasi bilan bog‘liq holda tahlil qilindi. Kuzatuv natijalari asosida yer osti suvlarining vaqt bo‘yicha o‘zgarish dinamikasi baholanib, suvli gorizontlarning oziqlanish va sarflanish sharoitlari haqida xulosalar chiqarildi. Yer osti suvlarining ichimlik suvi sifatidagi yaroqliligini va gidrogeokimyoviy xususiyatlarini baholash uchun tajriba va ekspluatatsion quduqlardan suv namunalari olindi. Namunalarda suvning mineralizatsiyasi, umumiy qattiqligi va asosiy kimyoviy tarkibiy komponentlari laboratoriya sharoitida aniqlanadi. Suvlarning mineralizatsiya darajasi va qattiqligi bo‘yicha olingan natijalar turli suvli gorizontlar kesimida taqqoslandi. Shuningdek, Sirdaryo va sug‘orish tarmoqlaridagi suvlarning gidrogeokimyoviy ko‘rsatkichlari yer osti suvlarining tarkibi bilan solishtirilib, yer usti va yer osti suvlari o‘rtasidagi mumkin bo‘lgan gidravlik va gidrogeokimyoviy bog‘liqlik baholandi. Yer osti suvlarining ekspluatatsion imkoniyatlarini baholashda quduqlarning suv sarfi, suv sathining pasayishi, solishtirma debiti, suvli qatlamlarning qalinligi va filtratsion xususiyatlari hisobga olindi. Mavjud VS-3 suv olish inshootining ishlash ko‘rsatkichlari yangi burg‘ilangan ekspluatatsion quduqlar natijalari bilan taqqoslandi. Bunda suv olish inshootining uzoq muddatli ishlash imkoniyati, quduqlar orasidagi o‘zaro ta’sir va suvli gorizontlardan olinishi mumkin bo‘lgan istiqbolli suv miqdori baholandi. Tadqiqot natijalarini fazoviy tahlil qilishda geologik va gidrogeologik kesimlar, quduqlarning joylashish sxemalari hamda gidrogeologik xaritalardan foydalanildi. Quduqlarning koordinatalari, suv sathi, suv sarfi, mineralizatsiyasi va boshqa gidrogeologik ko‘rsatkichlari o‘zaro taqqoslanib, hudud bo‘yicha yer osti suvlarining tarqalish qonuniyatlari aniqlandi. Olingan dala va laboratoriya ma’lumotlari statistik hamda qiyosiy tahlil qilinib, yer osti suvlarining miqdoriy va sifat ko‘rsatkichlari bo‘yicha umumiy baho berildi. [2]

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Координаты угловых точек

1.)	В.Д. 69°1'20,816"	С.Ш. 40°43'15,617"
2.)	В.Д. 69°22'2,865"	С.Ш. 40°42'41,557"
3.)	В.Д. 69°0'35,737"	С.Ш. 40°11'20,409"
4.)	В.Д. 69°20'46,296"	С.Ш. 40°10'25,705"

1-rasm. Bekobod tumani sharh xaritasi

Adabiyotlar tahlili

Bekobod shahri va unga tutash hududlarning yer osti suvlarini o‘rganish bo‘yicha tadqiqotlar hududning murakkab geologik-gidrogeologik tuzilishi, sug‘oriladigan yerlarning keng tarqalganligi hamda Sirdaryo va sug‘orish tarmoqlarining yer osti suvlariga ta’siri bilan bog‘liq. Markaziy Osiyoda yer osti suvlarining asosiy qismi to‘rtlamchi va pliosen davrlarining allyuvial, tog‘oldi prolyuvial va vodiy yotqiziqlarida shakllanganligi qayd etilgan. Dalverzin hududi gidrogeologik jihatdan alohida ahamiyatga ega bo‘lib, zamonaviy tadqiqotlarda Dalverzin yer osti suvlari koni Sirdaryoning o‘ng qirg‘og‘idagi transchegaraviy akviferlardan biri sifatida ko‘rsatilgan. Mazkur suvli kompleks tarkibida to‘rtlamchi va bo‘r davri yotqiziqlari ishtirok etishi qayd etilgan. Bu holat hududdagi yer osti suvlarining shakllanishi va tarqalishini baholashda geologik-litologik sharoitlarni hisobga olish zarurligini ko‘rsatadi. Bekobod va Dalverzin hududidagi yer osti suvlarining shakllanishida Sirdaryo, sug‘orish kanallari va tog‘oldi hududlardan keluvchi yer osti oqimlari muhim ahamiyatga ega. Bekobod hududi bo‘yicha zamonaviy ekologik-gidrogeologik tadqiqotlarda yer osti suvlarining Dalverzin kanali, Bayovut, Janubiy Mirzacho‘l, Do‘stlik va Derivatsiya kanallari orqali infiltratsion oziqlanishi hamda Mog‘ultovning g‘arbiy yonbag‘irlaridan keluvchi oqimlar bilan bog‘liqligi ko‘rsatilgan. Shuningdek, sug‘oriladigan maydonlar va irrigatsiya inshootlarining yer osti suvlarining yotish chuqurligiga ta’sir ko‘rsatishi aniqlangan. Sirdaryo havzasida yer osti suvlarining miqdoriy va sifat ko‘rsatkichlari bo‘yicha olib borilgan tadqiqotlar ayniqsa sug‘oriladigan hududlarda yer osti suvlari sathi va minerallashuvining uzoq muddatli o‘zgarishlarini aniqlashga qaratilgan. Khasanov va hammualliflarining tadqiqotida Sirdaryo viloyatining sug‘oriladigan hududlarida 2000–2019-yillar davomida yer osti suvlari sathi, minerallashuvi va tuproq sho‘rlanishining fazoviy-vaqt bo‘yicha o‘zgarishlari GIS texnologiyalari yordamida baholangan. Tadqiqotda katta hajmdagi dala ma’lumotlari va kuzatuv quduqlari ma’lumotlaridan foydalanilgan. Mazkur tadqiqotlarning muhim jihati shundaki, yer osti suvlari sathi va minerallashuvi sug‘oriladigan hududlarning meliorativ holatini belgilovchi asosiy omillardan biri sifatida qaraladi. Tadqiqotchilar yer osti suvlarining sathi va minerallashuvini muntazam monitoring qilish, sug‘orish suvlaridan samarali foydalanish hamda drenaj tizimlarining ishlash holatini nazorat qilish zarurligini ta’kidlaganlar. Sirdaryo suvining gidrokimyoviy tarkibi ham Bekobod hududidagi yer osti suvlarini o‘rganishda muhim ahamiyatga ega. Mavjud ma’lumotlarga ko‘ra, Sirdaryoning Bekobod yaqinidagi suvlarida minerallashuv yuqori oqimdagi ayrim uchastkalarga nisbatan ortadi. Zamonaviy tadqiqotlarda Bekobod posti ham Sirdaryoning o‘rta oqimidagi suv sifatini baholash uchun asosiy kuzatuv nuqtalaridan biri sifatida foydalanilgan. So‘nggi yillarda gidrogeologik tadqiqotlarda GIS texnologiyalaridan foydalanish kengayib bormoqda. Sirdaryo viloyatida yer osti suvlarining sathi va minerallashuvini fazoviy xaritalashda

IDW interpolatsiyasi qo‘llanilib, dala kuzatuvlari bilan GIS natijalarining aniqligi baholangan. Bunday yondashuv yer osti suvlarining fazoviy taqsimlanishini aniqlash va gidrogeologik monitoring natijalarini xaritalash imkonini beradi. [3]

Tahlil va natijalar

Tadqiqot hududining geologik va gidrogeologik tuzilishini tahlil qilish natijasida Bekobod-Dalverzin hududida yer osti suvlarining shakllanishi va tarqalishi hududning geologik-litologik tuzilishi, Sirdaryo vodiysi, tog‘oldi prolyuvial yotqiziqlari hamda sug‘orish tizimlari bilan chambarchas bog‘liqligi aniqlandi. Hududning asosiy suvli qatlamlari to‘rtlamchi va neogen davrlarining g‘ovak-suv o‘tkazuvchi yotqiziqlari bilan bog‘langan. Tadqiqot hududida to‘rtlamchi yotqiziqlarning umumiy qalinligi 130–280 m gacha o‘zgaradi. Ular asosan shag‘al, galka, qum va graviydan tashkil topgan bo‘lib, ayrim joylarda suglinka va supes qatlamlari hamda linzalari uchraydi. Daryo vodiysining markaziy qismida yirik donali suv o‘tkazuvchi jinslar keng rivojlanganligi sababli bu hudud yer osti suvlarini to‘plash va uzatish uchun qulay sharoitga ega. Tahlillar shuni ko‘rsatadiki, to‘rtlamchi yotqiziqlar kesimida ikki asosiy suvli gorizontni ajratish mumkin: zamonaviy va yuqori to‘rtlamchi allyuvial-prolyuvial yotqiziqlardagi grunt suvlari hamda o‘rta-quyi to‘rtlamchi allyuvial-prolyuvial yotqiziqlardagi naporli suvlar. Ularning ajratilishiga litologik qatlamlarning mavjudligi, filtratsion xususiyatlarning farqlanishi va suv sathlari orasidagi tafovut asos bo‘lgan. Ayniqsa 60-80 m chuqurliklarda uchraydigan suglinka va supes qatlamlari yuqoridagi va pastdagi suvli qatlamlar o‘rtasida nisbiy suv o‘tkazmaydigan qatlam sifatida namoyon bo‘ladi. Natijada pastki suvli gorizontlarda napor hosil bo‘ladi. Yuqori va pastki qismlarning filtratsion xususiyatlari ham bir-biridan farq qiladi.

Tadqiqot natijalariga ko‘ra, Dalverzin tekisligidagi grunt suvlarining asosiy oziqlanish manbalarini sug‘orish kanallari, ariqlar, sug‘oriladigan maydonlardan infiltratsiya qilinadigan suvlar hamda Utkemsay konus yoyilmasi va tog‘ massivlari tomonidan keladigan yer osti oqimi tashkil etadi. Sirdaryoning grunt suvlariga ta’siri asosan hududning janubiy qismida va daryoning toshqin davrlarida namoyon bo‘ladi. Grunt suvlarining sathi hudud bo‘yicha bir xil emas. Asosiy maydonda ularning chuqurligi 3–5 m ni tashkil etadi. Ayrim kollektorlar va Dalverzin kanalining ayrim qismlari bo‘ylab suv sathi 3 m gacha ko‘tariladi, boshqa hududlarda esa 5–9 m chuqurlikda joylashadi. Grunt suvlarining mavsumiy rejimi sug‘orish suvlarining berilishiga bog‘liq bo‘lib, eng past sath mart oyida, yuqori sath esa iyul-sentabr oylarida kuzatiladi. Yer osti suvlarining umumiy harakat yo‘nalishi janubi-sharqdan shimoli-g‘arbga qarab yo‘nalgan. Grunt suvlari oqimining gidravlik nishabi 0,0004-0,001, naporli suvli gorizontlarda esa 0,001-0,002 oralig‘ida qayd etilgan. O‘rganilgan hududdagi o‘rta-quyi to‘rtlamchi suvli gorizont yuqori suv beruvchanligi bilan ajralib turadi. Markaziy qismdagi quduqlarda solishtirma suv sarfi 5-10 l/s gacha, batafsil razvedka hududida esa 9,6-19,0 l/s gacha yetgan. Quduqlarning umumiy suv sarfi markaziy qismda 10-44 l/s, batafsil razvedka uchastkasida esa 56,4-98,0 l/s ni tashkil qilgan. Biroq allyuvial qatlamlarning janubi-g‘arbiy va janubi-sharqiy yo‘nalishlarda, ya’ni ularning chekka qismlarida siyraklashishi natijasida suv beruvchanlik kamayadi. Ushbu hududlarda solishtirma suv sarfi 2,0-2,7 l/s gacha pasayadi. Bu holat suvli qatlamlarning markaziy qismida yirik donali galka va graviylarning keng tarqalganligi, chekka qismlarda esa mayda donali va nisbatan kam o‘tkazuvchan jinslarning ulushi ortishi bilan izohlanadi. [4]

Gidrogeokimyoviy tahlil natijalari suv sifatining hudud bo‘yicha sezilarli darajada o‘zgarishini ko‘rsatadi. Zamonaviy va yuqori to‘rtlamchi yotqiziqlardagi grunt suvlarining minerallashuvi ayrim maydonlarda 1,6-1,8 g/l gacha, umumiy qattiqligi esa 16–19 mg-ekv/l gacha yetadi. Shu sababli yuqori qismdagi grunt suvlarining bir qismi xo‘jalik-ichimlik suv ta’minoti uchun cheklangan imkoniyatga ega. Bunga qarama-qarshi ravishda, o‘rta-quyi to‘rtlamchi yotqiziqlardagi suvlarning minerallashuvi hududning katta qismida 0,2-0,5 g/l ni tashkil qiladi. Janubiy, g‘arbiy va janubi-sharqiy yo‘nalishlarda ushbu ko‘rsatkich 0,7-0,8 g/l gacha ortadi. Umumiy qattiqlik 1,8-6,8 mg-ekv/l oralig‘ida qayd etilgan. [5]

Neogen suvli gorizontlarida ham nisbatan yaxshi gidrogeokimyoviy ko‘rsatkichlar qayd etilgan. Dalverzin tekisligining asosiy qismida minerallashuv 0,46-0,61 g/l, umumiy qattiqlik esa markaziy qismda 4,5 mg-ekv/l atrofida bo‘lgan. Biroq Sirdaryoning chap qirg‘og‘i tomon minerallashuv 1 g/l dan oshib, ayrim quduqlarda 1,04-1,92 g/l gacha yetgan. Tadqiqot natijalari Bekobod shahrining markazlashtirilgan xo‘jalik-ichimlik suv ta’minoti uchun o‘rta-quyi to‘rtlamchi hamda neogen yotqiziqlaridagi suvli gorizontlarning muhim istiqbolga ega ekanligini ko‘rsatadi. Avvalgi razvedka ishlari natijasida o‘rta-quyi to‘rtlamchi yotqiziqlardagi yer osti suvlarining ekspluatatsion zaxiralari 156 ming m^3/kun miqdorida tasdiqlangan va keyinchalik VS-3 suv olish inshooti qurilgan. Shu bilan birga, 2015-2018-yillardagi ekologik-gidrogeologik tadqiqotlarda Dalverzin konining yuqori to‘rtlamchi qatlamlaridagi suvlarning sifat ko‘rsatkichlari yomonlashgani qayd etilgan. Shu sababli istiqbolli manba sifatida yuqori pliosen yotqiziqlarida 350 m va undan katta chuqurliklarda joylashgan suvli gorizontlarni o‘rganish tavsiya etilgan. Oldingi va yangi tadqiqotlar natijalarini taqqoslash shuni ko‘rsatadiki, chuqur joylashgan neogen suvli gorizontlarini qo‘shimcha o‘rganish Bekobod shahri suv ta’minotini yaxshilashning muhim yo‘nalishlaridan biri hisoblanadi. Ayniqsa, 200-400 m chuqurlik

oralig‘idagi suvli qatlamlarda nisbatan sifatli yer osti suvlarini izlash istiqbolli yo‘nalish sifatida ko‘rsatilgan. Bekobod meteorologik stansiyasi ma’lumotlari bo‘yicha ko‘p yillik o‘rtacha yillik havo harorati 15,4 °C, nisbiy namlikning yillik o‘rtacha qiymati 67% ni tashkil qiladi. Eng yuqori o‘rtacha harorat iyul oyida 28,3 °C, eng past qiymat yanvarda 1,8 °C kuzatiladi. Atmosfera yog‘inlarining ko‘p yillik o‘rtacha miqdori 28,5 mm/oy bo‘lib, yog‘inlarning asosiy qismi qish-bahor oylariga to‘g‘ri keladi. Yoz oylarida yog‘in miqdori keskin kamayib, iyulda o‘rtacha 3,1 mm, avgustda 3,5 mm va sentabrda 4,6 mm ni tashkil etadi. Bu holat hududda yer osti suvlarining tabiiy atmosfera yog‘inlari hisobiga oziqlanishidan ko‘ra, sug‘orish tizimlari va infiltratsion jarayonlarning ahamiyati yuqori ekanligini ko‘rsatadigan muhim tabiiy omillardan biridir. Umuman olganda, tadqiqot natijalari Bekobod–Dalverzin hududida yer osti suvlarining miqdoriy va sifat ko‘rsatkichlari geologik-litologik tuzilish, sug‘orish tizimi, yer osti oqimi va chuqurlik bo‘yicha sezilarli darajada farqlanishini ko‘rsatdi. Yuqori to‘rtlamchi grunt suvlari sug‘orish va kollektor-drenaj tizimlari ta’sirida shakllanib, ayrim uchastkalarda yuqori minerallashuv va qattiqlik bilan tavsiflanadi. O‘rta-quyi to‘rtlamchi hamda ayrim neogen suvli gorizontlarida esa nisbatan past minerallashuv va yuqori suv beruvchanlik kuzatiladi. Shu asosda VS-3 suv olish inshootining istiqbolini baholashda faqat mavjud ekspluatatsion quduqlarning suv sarfini emas, balki chuqur neogen suvli gorizontlarining gidrogeologik va gidrogeokimyoviy xususiyatlarini ham hisobga olish zarur. Mavjud ma’lumotlar chuqur suvli gorizontlarni 200-400 m oralig‘ida qo‘shimcha o‘rganish, ularning ekspluatatsion zaxiralarini zamonaviy dala va tajriba ishlari asosida aniqlashtirish zarurligini ko‘rsatadi. [6]

Xulosa

Bekobod shahri va Bekobod tumani hududidagi yer osti suvlarining gidrogeologik sharoitlarini o‘rganish natijasida hududning suv resurslari geologik-litologik tuzilish, Sirdaryo vodiysi, tog‘oldi prolyuvial yotqiziqlari hamda sug‘orish tizimlari bilan uzviy bog‘liq ekanligi aniqlandi. Tadqiqot natijalari to‘rtlamchi va neogen davri yotqiziqlarida shakllangan suvli gorizontlar hududning asosiy istiqbolli yer osti suv manbalari ekanligini ko‘rsatdi. Tadqiqot hududida to‘rtlamchi yotqiziqlarning qalinligi 130–280 m gacha o‘zgarib, ular asosan galka, shag‘al, graviy va qum kabi yuqori filtratsion xususiyatga ega jinslardan tashkil topgan. Litologik kesimda suglinka va supes qatlamlarining mavjudligi natijasida zamonaviy-yuqori to‘rtlamchi hamda o‘rta-quyi to‘rtlamchi suvli gorizontlarni ajratish imkoniyati mavjud. Yer osti suvlarining asosiy oziqlanish manbalari sug‘orish kanallari, ariqlar, sug‘oriladigan maydonlardan infiltratsiya qilinadigan suvlar hamda Utkemsay konus yoyilmasi va tog‘oldi hududlaridan keluvchi yer osti oqimlaridan iborat. Grunt suvlarining sathi hududning asosiy qismida 3–5 m, ayrim uchastkalarda esa 5–9 m chuqurlikda joylashgan. Yer osti suvlarining umumiy harakat yo‘nalishi janubi-sharqdan shimoli-g‘arbga tomon yo‘nalgan.

O‘rta-quyi to‘rtlamchi suvli gorizontlarning suv beruvchanligi yuqori ekanligi aniqlandi. Markaziy qismdagi quduqlarda solishtirma suv sarfi 5–10 l/s, batafsil o‘rganilgan uchastkada 9,6–19,0 l/s gacha yetadi. Ayrim quduqlarda umumiy suv sarfi 56,4–98,0 l/s gacha qayd etilgan. Bu ko‘rsatkichlar mazkur suvli gorizontlarning markazlashtirilgan suv ta’minoti uchun muhim gidrogeologik salohiyatga ega ekanligini ko‘rsatadi. Gidrogeokimyoviy tahlillar suv sifati chuqurlik va hududiy joylashuvga qarab sezilarli farqlanishini ko‘rsatdi. Yuqori to‘rtlamchi grunt suvlarida minerallashuv ayrim hududlarda 1,6–1,8 g/l, umumiy qattiqlik 16–19 mg-ekv/l gacha yetadi. O‘rta-quyi to‘rtlamchi suvli gorizontlarda esa minerallashuv asosan 0,2–0,5 g/l, qattiqlik 1,8–6,8 mg-ekv/l oralig‘ida qayd etilgan. Neogen suvli gorizontlari ham ichimlik suv ta’minoti nuqtayi nazaridan istiqbolli ekanligi aniqlandi. Dalverzin tekisligining asosiy qismida ushbu suvlarning minerallashuvi 0,46–0,61 g/l ni tashkil etadi. Shu bilan birga, hududning ayrim qismlarida minerallashuvning 1 g/l dan yuqori qiymatlarga ko‘tarilishi kuzatiladi. Bu holat neogen suvli gorizontlarining gidrogeokimyoviy sharoitlarini hududiy jihatdan batafsil o‘rganish zarurligini ko‘rsatadi. Mavjud ma’lumotlar VS-3 suv olish inshootining uzoq muddatli ekspluatatsiyasida suvning nafaqat miqdoriy, balki sifat ko‘rsatkichlarini ham muntazam nazorat qilish zarurligini ko‘rsatadi. Avvalgi tadqiqotlarda o‘rta-quyi to‘rtlamchi yotqiziqlardagi yer osti suvlarining ekspluatatsion zaxiralari 156 ming m³/kun miqdorida tasdiqlangan bo‘lsa, keyingi ekologik-gidrogeologik tadqiqotlarda yuqori to‘rtlamchi suvlarning sifat ko‘rsatkichlarida yomonlashish qayd etilgan. Shu munosabat bilan 200–400 m chuqurlikdagi neogen, xususan yuqori pliosen suvli gorizontlarini qo‘shimcha o‘rganish Bekobod shahri va tumani uchun istiqbolli yo‘nalish sifatida qaraladi. Bunda yangi qidiruv-razvedka quduqlarini burg‘ilash, tajriba-suv chiqarish ishlarini bajarish, pyezometrik sathlarning dinamikasini kuzatish va suvlarning gidrogeokimyoviy tarkibini muntazam tahlil qilish maqsadga muvofiq. Umuman, tadqiqot natijalari Bekobod–Dalverzin hududida yer osti suvlaridan oqilona foydalanish uchun kompleks gidrogeologik monitoring tizimini tashkil etish zarurligini ko‘rsatadi. Bunda suv sarfi, suv sathi, minerallashuv, umumiy qattiqlik va asosiy gidrogeokimyoviy komponentlarning vaqt bo‘yicha o‘zgarishini birgalikda kuzatish mavjud suv olish inshootlarining ekspluatatsion barqarorligini baholash va istiqbolli suv resurslarini boshqarish imkonini beradi.

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Zamonaviy tarjimashunoslikning rivojlanish tendensiyalari

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Annotatsiya

Mazkur maqolada zamonaviy tarjimashunoslik fanining rivojlanish yo‘nalishlari, tarjima jarayoniga raqamli texnologiyalar va sun’iy intellektning kirib kelishi, mashina tarjimasi, korpus lingvistikasi, audiovizual tarjima, lokalizatsiya, tarjimon kompetensiyasi hamda tarjima jarayonining fanlararo xususiyatlari tahlil qilinadi. Bugungi kunda tarjimashunoslik an’anaviy lingvistik yondashuv doirasidan chiqib, kompyuter lingvistikasi, kognitiv fanlar, raqamli gumanitar fanlar va axborot texnologiyalari bilan chambarchas bog‘lanmoqda. Zamonaviy tadqiqotlarda tarjima sifatini baholash, inson va sun’iy intellekt hamkorligi, madaniy moslashtirish hamda lingvistik xilma-xillikni ta’minlash masalalariga alohida e’tibor qaratilmoqda.

Kalit so‘zlar: tarjimashunoslik, tarjima nazariyasi, mashina tarjimasi, sun’iy intellekt, neyron tarjima, korpus lingvistikasi, audiovizual tarjima, lokalizatsiya, tarjimon kompetensiyasi, lingvistik xilma-xillik.

Аннотация

В данной статье анализируются основные направления развития современного переводоведения, внедрение цифровых технологий и искусственного интеллекта в процесс перевода, машинный перевод, корпусная лингвистика, аудиовизуальный перевод, локализация, компетенции переводчика, а также междисциплинарный характер переводческого процесса. В настоящее время переводоведение выходит за рамки традиционного лингвистического подхода и тесно взаимодействует с компьютерной лингвистикой, когнитивными науками, цифровыми гуманитарными науками и информационными технологиями. В современных исследованиях особое внимание уделяется оценке качества перевода, взаимодействию человека и искусственного интеллекта, культурной адаптации, а также обеспечению языкового разнообразия.

Ключевые слова: переводоведение, теория перевода, машинный перевод, искусственный интеллект, нейронный перевод, корпусная лингвистика, аудиовизуальный перевод, локализация, компетенции переводчика, языковое разнообразие.

Abstract

This article analyzes the major directions in the development of modern translation studies, the integration of digital technologies and artificial intelligence into the translation process, machine translation, corpus linguistics, audiovisual translation, localization, translator competence, and the interdisciplinary nature of the translation process. Today, translation studies has moved beyond the framework of traditional linguistic approaches and has become closely interconnected with computational linguistics, cognitive sciences, digital humanities, and information technologies. Contemporary research pays particular attention to translation quality assessment, human–artificial intelligence collaboration, cultural adaptation, and the preservation of linguistic diversity.

Keywords: translation studies, translation theory, machine translation, artificial intelligence, neural machine translation, corpus linguistics, audiovisual translation, localization, translator competence, linguistic diversity.

Kirish

Tarjima insoniyatning turli xalqlar va madaniyatlar o‘rtasidagi aloqalarini ta’minlab kelayotgan muhim vositalardan biridir. Globallashuv, xalqaro hamkorlik, internet va raqamli kommunikatsiyaning jadal rivojlanishi natijasida tarjimaga bo‘lgan ehtiyoj tobora ortib bormoqda. Shu bilan birga, tarjima faoliyatining mazmuni va shakli ham sezilarli darajada o‘zgarmoqda.

An’anaviy tarjimashunoslik asosan tarjima ekvivalentligi, adekvatlik, tarjima transformatsiyalari, uslub va madaniy muvofiqlik kabi masalalarni o‘rgangan bo‘lsa, zamonaviy tarjimashunoslik texnologik va fanlararo xarakter kasb etmoqda. 2020–2024-yillardagi ilmiy nashrlarni tahlil qilgan bibliometrik tadqiqotlarda neyron mashina tarjimasi, sun’iy intellekt, kognitiv yondashuv, audiovizual tarjima, tarjimon tayyorlash va tarjima etikasi kabi mavzularning faollashgani qayd etilgan.

1. Sun’iy intellekt va mashina tarjimasining rivojlanishi

Zamonaviy tarjimashunoslikning eng muhim tendensiyalaridan biri — sun’iy intellekt va mashina tarjimasi texnologiyalarining jadal rivojlanishidir. Ayniqsa, neyron mashina tarjimasi tarjima jarayonining tezligi va ko‘lamini sezilarli darajada oshirdi.

Bugungi kunda mashina tarjimasi faqat oddiy so‘z yoki gaplarni tarjima qilish vositasi bo‘lib qolmay, katta hajmdagi hujjatlar, veb-saytlar, texnik materiallar va multimedia kontentini qayta ishlashda ham qo‘llanmoqda. Tadqiqotlarda mashina tarjimasi tarjimon faoliyatini butunlay almashtirishdan ko‘ra, tarjimon ishini avtomatlashtirish va unga yordam berish vositasi sifatida ko‘proq namoyon bo‘layotgani ta’kidlanadi. Audiovizual tarjimada ham mashina tarjimasi va post-tahrirlash amaliyotlari kengayib, tarjimonning vazifalari va kasbiy profillarini o‘zgartirmoqda.

Shu sababli zamonaviy tarjimon uchun nafaqat yuqori darajadagi til bilimiga, balki CAT vositalari, mashina tarjimasi tizimlari va post-tahrirlash texnologiyalaridan foydalanish ko‘nikmalariga ega bo‘lish ham muhim hisoblanadi.

2. Korpus lingvistikasining tarjimashunoslikdagi o‘rni

Tarjimashunoslikning yana bir muhim rivojlanish yo‘nalishi korpus lingvistikasi bilan bog‘liq. Elektron korpuslar katta hajmdagi original va tarjima matnlarini tizimli ravishda tahlil qilish imkonini beradi.

Korpusga asoslangan tadqiqotlar orqali tarjimon uslubi, tarjima me’yorlari, ekvivalentlik, tarjima universallari va boshqa ko‘plab hodisalarni empirik ma’lumotlar asosida o‘rganish mumkin. 2024-yilda chop etilgan tadqiqot korpus tarjimashunosligida ko‘p metodli va fanlararo yondashuvlarning ahamiyati ortib borayotganini ko‘rsatadi.

3. Audiovizual tarjima va lokalizatsiyaning kengayishi

Internet, videoplatformalar, striming xizmatlari va raqamli media vositalarining rivojlanishi audiovizual tarjimaga bo‘lgan talabni oshirdi. Subtitrlash, dublyaj, ovozli tarjima, audio-tavsif va boshqa shakllar bugungi tarjimashunoslikning muhim tadqiqot obyektlariga aylandi.

Audiovizual tarjima bo‘yicha bibliometrik tadqiqotlar ushbu yo‘nalishning so‘nggi yigirma yil ichida jadal rivojlanganini ko‘rsatadi. Tadqiqotlarda subtitrlash bilan bir qatorda media imkoniyatlaridan nogironligi bo‘lgan shaxslar foydalanishini ta’minlash, virtual reallik, videoo‘yinlar lokalizatsiyasi va mashina tarjimasi kabi mavzular ham paydo bo‘lgan.

Lokalizatsiya esa oddiy tarjimadan farqli ravishda mahsulot yoki kontentni muayyan mamlakat va madaniyat auditoriyasiga moslashtirishni nazarda tutadi. Shu jihatdan zamonaviy tarjimon til bilimidan tashqari madaniyatlararo kommunikatsiya va raqamli mahsulotlarning xususiyatlarini ham yaxshi bilishi kerak.

4. Inson va sun’iy intellekt hamkorligi

Zamonaviy tarjimashunoslikda “inson yoki mashina” qarama-qarshiligidan ko‘ra, “inson va texnologiya hamkorligi” masalasi tobora muhimlashmoqda.

Sun’iy intellekt katta hajmdagi matnni tez qayta ishlashi mumkin, biroq terminologik nozikliklar, kontekst, kinoya, metafora, madaniy ishoralar va badiiy uslubni to‘g‘ri talqin qilishda inson tarjimonining roli saqlanib qolmoqda. Shu sababli post-tahrirlash, sifat nazorati va tarjima natijasini inson tomonidan tekshirish zamonaviy tarjima jarayonining muhim bosqichlariga aylanmoqda. Tadqiqotlarda AI asosidagi media lokalizatsiyasi tarjimonlarning ish jarayoni, kasbiy barqarorligi va ta’limiga ham ta’sir ko‘rsatayotgani qayd etiladi.

5. Multimodal va ko‘pkanalli tarjima

Yangi texnologiyalar tarjimani faqat yozma matn bilan chegaralab qo‘ymayapti. Zamonaviy tizimlarda matn, tasvir, audio va video kabi turli axborot shakllarini birgalikda qayta ishlashga e’tibor kuchaymoqda.

2025-yilgi EMNLP tadqiqotlaridan birida multimodal neyron mashina tarjimasi, ya’ni matn bilan bir qatorda vizual ma’lumotlardan ham foydalanadigan tarjima tizimlari tahlil qilingan. Bunday yondashuv elektron savdo, ijtimoiy media va boshqa ko‘pkanalli kommunikatsiya muhitlarida qo‘llanilishi mumkin.

Shunday qilib, kelajakdagi tarjimashunoslik uchun multimodallik muhim tadqiqot yo‘nalishlaridan biri bo‘lib qolishi mumkin.

6. Lingvistik xilma-xillik va kam resursli tillar

Raqamli texnologiyalar rivojlanishi bilan barcha tillarning texnologik imkoniyatlarini ta’minlash masalasi ham dolzarb bo‘lib bormoqda. Ayrim yirik tillar uchun katta hajmdagi raqamli ma’lumotlar mavjud bo‘lsa, ko‘plab kichik yoki kam resursli tillar uchun bunday ma’lumotlar yetarli emas.

UNESCO raqamli davrda barcha tillarning texnologik jihatdan qo‘llab-quvvatlanishi, xususan, kam resursli va yo‘qolib borayotgan tillarning raqamli muhitda mavjudligini mustahkamlash zarurligini ta’kidlamoqda. Tashkilotning 2025-yilda taqdim etilgan Global Roadmap hujjatida mashina tarjimasi, nutqni tanish va tabiiy tilni qayta ishlash kabi texnologiyalar lingvistik xilma-xillikni qo‘llab-quvvatlash vositasi sifatida ko‘rsatiladi.

Bu jarayon o‘zbek tilining ham raqamli resurslarini rivojlantirish, sifatli parallel korpuslar yaratish, terminologik bazalarni kengaytirish va o‘zbek tilidagi AI vositalarini takomillashtirish zaruratini ko‘rsatadi.

7. Tarjimon kompetensiyasiga qo‘yilayotgan yangi talablar

Texnologik taraqqiyot tarjimonning kasbiy kompetensiyasiga qo‘yiladigan talablarni ham o‘zgartirmoqda. Zamonaviy tarjimon quyidagi ko‘nikmalarga ega bo‘lishi muhim:

- yuqori darajadagi ona tili va chet tili kompetensiyasi;
- madaniyatlararo kommunikativ kompetensiya;
- terminologiya bilan ishlash ko‘nikmasi;
- elektron lug‘atlar va korpuslardan foydalanish;
- CAT vositalaridan foydalanish;
- mashina tarjimasini tahrirlash va sifatini baholash;
- axborotni izlash va tekshirish ko‘nikmasi;
- tarjima etikasi va mualliflik huquqi masalalarini bilish.

Shu sababli tarjimonlarni tayyorlash dasturlarida an’anaviy nazariy bilimlar bilan bir qatorda raqamli texnologiyalar va sun’iy intellekt vositalaridan foydalanish bo‘yicha amaliy mashg‘ulotlarga ham e’tibor qaratish zarur.

Xulosa qilib aytganda, zamonaviy tarjimashunoslik jadal o‘zgarishlar bosqichini boshdan kechirmoqda. Uning asosiy rivojlanish tendensiyalarini sun’iy intellekt va neyron mashina tarjimasining rivojlanishi, korpus lingvistikasining keng qo‘llanilishi, audiovizual tarjima va lokalizatsiyaning ommalashuvi, multimodal tarjima, inson va texnologiya hamkorligi, lingvistik xilma-xillikni qo‘llab-quvvatlash hamda fanlararo tadqiqotlarning kuchayishi bilan izohlash mumkin.

Texnologiyalar tarjima jarayonini tezlashtirayotgan bo‘lsa-da, tarjimaning madaniy, kommunikativ va ijodiy jihatlari inson omilining ahamiyatini saqlab qolmoqda. Shu sababli kelajak tarjimashunosligining asosiy vazifalaridan biri inson tarjimonining tajribasi va sun’iy intellekt imkoniyatlarini samarali uyg‘unlashtirishdan iborat bo‘ladi.

Zamonaviy tarjimashunoslik bugungi kunda tilshunoslikning jadal rivojlanayotgan yo‘nalishlaridan biri hisoblanadi. Globallashuv, xalqaro aloqalarning kengayishi, axborot-kommunikatsiya texnologiyalarining rivojlanishi hamda turli xalqlar o‘rtasidagi madaniy almashinuvning kuchayishi tarjimaga bo‘lgan ehtiyojni sezilarli darajada oshirmoqda. Shu bilan birga, tarjima jarayonining mazmuni, usullari va vositalari ham tubdan o‘zgarib bormoqda. Ilgari tarjima asosan ikki til o‘rtasidagi lingvistik vositalarni almashtirish jarayoni sifatida qaralgan bo‘lsa, bugungi tarjimashunoslik uni lingvistik, madaniy, kognitiv, kommunikativ va texnologik jihatlarni qamrab oluvchi murakkab jarayon sifatida o‘rganmoqda.

Tarjimashunoslikning zamonaviy rivojlanishida, avvalo, fanlararo yondashuvning kuchayishini kuzatish mumkin. Hozirgi tadqiqotlarda tarjima lingvistika bilan bir qatorda psixologiya, kognitiv fanlar, madaniyatshunoslik, sotsiologiya, kompyuter lingvistikasi va axborot texnologiyalari bilan uzviy bog‘liq holda o‘rganilmoqda. Bunday yondashuv tarjima jarayonida tarjimonning fikrlash faoliyati, qaror qabul qilishi, madaniy bilimlari va kommunikativ maqsadlarini chuqurroq tahlil qilish imkonini beradi. Natijada tarjimashunoslik faqat tarjima natijasini emas, balki tarjimonning ushbu natijaga qanday erishganini ham o‘rganishga e’tibor qaratmoqda.

Zamonaviy tarjimashunoslikning eng muhim tendensiyalaridan biri raqamlashtirish va sun’iy intellekt texnologiyalarining tarjima jarayoniga kirib kelishidir. Mashina tarjimasi, neyron tarmoqlar, avtomatik tarjima dasturlari va tarjimonlarga yordam beruvchi kompyuter vositalari tarjima faoliyatining ajralmas qismiga aylanmoqda. Ayniqsa, neyron mashina tarjimasi texnologiyalarining rivojlanishi katta hajmdagi matnlarni qisqa vaqt ichida qayta

ishlash imkonini bermoqda. Biroq avtomatik tarjima natijasi har doim ham inson tarjimasining barcha xususiyatlarini to‘liq aks ettira olmaydi. Kontekst, kinoya, obrazlilik, frazeologik birliklar, milliy-madaniy tushunchalar va uslubiy nozikliklarni to‘g‘ri talqin qilishda inson tarjimonining roli muhimligicha qolmoqda.

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SCIENCE FOR A SUSTAINABLE CENTRAL ASIA

Karp (*Cyprinus carpio* L.) yetishtirishda oziqlantirish, suv sifati va sog‘liqni boshqarish: barqaror akvakultura yondashuvi

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Annotatsiya

Ushbu maqolada oddiy karp (*Cyprinus carpio* L.) yetishtirishda mahsuldorlikni belgilovchi boshqaruv omillari — oziqlantirish strategiyasi, suvning fizik-kimyoviy holati, baliq zichligi, stressni kamaytirish va kasalliklarning oldini olish masalalari ilmiy adabiyotlar asosida tahlil qilinadi. Karpning omnivor oziqlanish xususiyati hovuz ekotizimidagi tabiiy oziqa resurslaridan foydalanish imkonini beradi, biroq yuqori zichlikdagi yetishtirishda qo‘shimcha yemning miqdori va berish rejimini nazorat qilish zarur. FAO ma’lumotlarida karpning kunlik o‘sishi tana massasining 2–4 foizigacha yetishi mumkinligi, subtropik va tropik polikultura hovuzlarida bir mavsumda 0,6–1,0 kg gacha o‘sishi, mo‘tadil sharoitlarda esa 1–2 kg massaga erishish uchun odatda 2–4 yetishtirish mavsumi talab qilinishi qayd etilgan. Maqolada kasalliklarning paydo bo‘lishida ekologik stress, suv sifati va xo‘jalik amaliyotining o‘rni ko‘rib chiqilib, profilaktik bioxavfsizlik choralarining ahamiyati asoslanadi. Shuningdek, yemni me’yorlash, suv parametrlarini muntazam monitoring qilish, karantin va sanitariya tadbirlarini bir tizimda qo‘llash barqaror karp yetishtirishning muhim shartlari sifatida ko‘rsatiladi.

Kalit so‘zlar: *Cyprinus carpio*, akvakultura, oziqlantirish, suv sifati, baliq zichligi, stress, bioxavfsizlik, kasallik profilaktikasi, yem boshqaruvi, barqaror baliqchilik.

Abstract

This article analyzes the major management factors affecting common carp (*Cyprinus carpio* L.) production, with particular emphasis on feeding strategy, water quality, stocking density, stress reduction, and disease prevention. The omnivorous feeding behavior of common carp enables the species to utilize natural food resources in pond ecosystems; however, supplementary feeding must be carefully managed in high-density production systems. FAO information indicates that daily growth of carp may reach approximately 2–4% of body weight, while in subtropical and tropical polyculture ponds fish may reach 0.6–1.0 kg within one growing season. In temperate conditions, reaching 1–2 kg may require approximately 2–4 rearing seasons. The article examines the relationship between environmental stress, water quality, routine farming practices and disease occurrence. It emphasizes that biosecurity, quarantine, sanitation, appropriate feeding, and regular monitoring of water parameters should be integrated into a single health-management system. The proposed approach can contribute to more efficient and environmentally responsible common carp production.

Keywords: *Cyprinus carpio*, aquaculture, feeding, water quality, stocking density, stress, biosecurity, disease prevention, feed management, sustainable fish farming.

Kirish

Chuchuk suv akvakulturasida ishlab chiqarish samaradorligi faqat baliqning biologik imkoniyatlari bilan emas, balki xo‘jalikda boshqariladigan muhitning sifati bilan ham belgilanadi. Oddiy karp *Cyprinus carpio* L. uzoq vaqt davomida hovuz baliqchiligining asosiy obyektlaridan biri bo‘lib kelgan. Turning tabiiy va sun’iy oziqa manbalaridan foydalanishi uni turli intensivlikdagi tizimlarga moslashtiradi. FAO ma’lumotlariga ko‘ra, karp oziqa sifatida suv hasharotlari, lichinkalar, chuvalchanglar, mollyuskalar, zooplankton hamda o‘simlik materiallaridan foydalanadi va xo‘jalik sharoitida don mahsulotlarini ham samarali o‘zlashtiradi.

Biroq mahsuldorlikni oshirish maqsadida oziqlantirishni haddan tashqari kuchaytirish suvga organik yuklamani oshirishi, suv sifatining yomonlashishi va stressni kuchaytirishi mumkin. Baliq kasalliklari bo‘yicha ilmiy sharhlarda ham ekologik stress, odatiy xo‘jalik amaliyotlari va ifloslanish kasalliklarning yuzaga kelish xavfi bilan bog‘liqligi

ko‘rsatilgan. Shu sababli karp xo‘jaligida oziqlantirish va sog‘liqni boshqarishni bir-biridan alohida emas, balki yagona ishlab chiqarish tizimi sifatida ko‘rib chiqish zarur.

Materiallar va usullar

Maqolada *Cyprinus carpio* akvakulturasiga oid FAO texnik materiallari va xalqaro ilmiy jurnallarda e’lon qilingan sharh maqolalar tahlil qilindi. Oziqlantirish, o‘sish, suv sifati, reproduktiv boshqaruv va kasalliklar bo‘yicha ma’lumotlar qiyosiy-tahliliy usulda umumlashtirildi. Raqamli ko‘rsatkichlar manbalarda keltirilgan diapazonlar doirasida berildi va muayyan xo‘jalik uchun majburiy me’yor sifatida talqin qilinmadi.

1. Oziqlantirishni boshqarish va o‘sish

Karpning omnivor oziqlanish tipi hovuz ekotizimining tabiiy oziqa bazasidan foydalanish imkonini beradi. FAO ma’lumotlarida uning ratsionida hayvon kelib chiqishidagi oziqa obyektlari — hasharotlar, lichinkalar, chuvalchanglar, mollyuskalar va zooplankton bilan bir qatorda suv va quruqlik o‘simliklarining qismlari ham mavjudligi ko‘rsatiladi. Yuqori zichlikdagi hovuzlarda zooplanktonning ahamiyati ortishi mumkin.

Sun’iy yemlashda asosiy vazifa baliqning oziqa ehtiyojini qondirish bilan birga yemning suvga tushib qoladigan ortiqcha qismini kamaytirishdir. FAO akvakultura bo‘yicha oziqlantirish qo‘llanmasida yemni boshqarish nafaqat o‘sish, balki suv sifati va ishlab chiqarish barqarorligi bilan bog‘liq ekanligi ta’kidlanadi.

FAO karp uchun qulay sharoitlarda kunlik o‘sish tana massasining 2–4 foizigacha yetishi mumkinligini qayd etadi. Subtropik va tropik polikultura hovuzlarida 0,6–1,0 kg massaga bir vegetatsiya mavsumida erishish mumkin; mo‘tadil hududlarda esa 1–2 kg massaga yetish odatda 2–4 yetishtirish mavsumini talab qiladi.

2. Yem boshqaruvi va tabiiy oziqa bazasi

Yarim intensiv hovuz xo‘jaligida tabiiy oziqa bazasi ishlab chiqarish xarajatlarini kamaytiruvchi muhim omil bo‘lishi mumkin. Shu bilan birga, tabiiy oziqa miqdori mavsum, suv harorati, hovuzning biologik mahsuldorligi va baliq biomassasiga qarab o‘zgaradi. Shuning uchun qo‘shimcha yem miqdorini bir xil ko‘rsatkichda butun mavsum davomida saqlash biologik jihatdan asoslanmagan bo‘lishi mumkin.

Yem berish chastotasi va miqdorini baliqlarning haqiqiy iste’moliga qarab moslashtirish kerak. Yemning suvda uzoq vaqt qolishi uning parchalanishi va mikrobiologik jarayonlarning kuchayishiga sabab bo‘lishi mumkin. Bu esa suvning organik yuklamasini oshiradi. Shuning uchun yemni kichik porsiyalarda, baliqlarning faol oziqlanish davriga moslab berish ishlab chiqarish boshqaruvining muhim elementi hisoblanadi.

3. Suv sifati — ishlab chiqarishning asosiy muhiti

Baliq organizmi suv bilan bevosita aloqada bo‘lganligi sababli suvning fizik-kimyoviy holati uning fiziologik faoliyati, oziqa iste’moli va stress darajasiga ta’sir qiladi. Harorat, erigan kislorod, pH, ammiak va nitrit kabi ko‘rsatkichlar muntazam monitoring qilinishi lozim.

Suv sifatining yomonlashuvi baliqning oziqa iste’molini kamaytirishi, o‘sishni sekinlashtirishi va immun tizimiga tushadigan yuklamani oshirishi mumkin. Kasalliklar bo‘yicha ilmiy sharhlarda karp xo‘jaliklarida ekologik stress va ifloslanish kasalliklarning yuzaga kelishida muhim omillar sifatida ko‘rsatilgan.

Ko‘rsatkich	Boshqaruvdagi ahamiyati	Monitoring yondashuvi
Suv harorati	Metabolizm, yem iste’moli va o‘sish tezligiga ta’sir qiladi	Mavsumiy va kunlik o‘zgarishlarni qayd etish
Erigan kislorod	Nafas olish va stress bilan bevosita bog‘liq	Ayniqsa tong oldidan va issiq davrda nazorat
pH	Fiziologik muvozanat va suv kimyosiga ta’sir qiladi	Muntazam o‘lchash
Ammiak/nitrit	Yuqori konsentratsiyalar toksik stressni kuchaytirishi mumkin	Organik yuklama oshganda tez-tez tekshirish
Suvning loyqaligi	Yorug‘lik, fotosintez va tubdagi jarayonlarga ta’sir qiladi	Vizual va asbobiy baholash

4. Baliqlar zichligi va stress

Baliq zichligini oshirish suv havzasining tabiiy oziqa resurslaridan ko‘proq foydalanish imkonini berishi mumkin, biroq yuqori biomassa suvning kislorodga bo‘lgan talabini va organik yuklamani oshiradi. Shu sababli zichlikni belgilashda hovuzning suv almashinuvi, aeratsiya imkoniyati, tabiiy oziqa bazasi va yemlash darajasi birgalikda hisobga olinishi kerak.

Stress uzoq davom etganda baliqning fiziologik barqarorligi pasayishi va kasalliklarga moyillik oshishi mumkin. Karp kasalliklari bo‘yicha ilmiy sharhlar stress va xo‘jalikdagi muhit omillarini kasalliklar xavfi bilan bog‘laydi.

5. Karp kasalliklarining asosiy guruhlari

Karpda parazitar, zamburug‘li, bakterial va virusli kasalliklar uchrashi mumkin. Ilmiy sharhlarda *Saprolegnia* turlari zamburug‘li zararlanishlarning muhim sabablaridan biri, *Aeromonas hydrophila* va ayrim boshqa bakteriyalar bakterial kasalliklarning muhim qo‘zg‘atuvchilari sifatida qayd etilgan. Virusli kasalliklar qatorida spring viraemia of carp (SVC) va koi herpesvirus disease (KHVD) alohida ahamiyatga ega.

Virusli kasalliklarning iqtisodiy xavfi ayniqsa yuqori bo‘lishi mumkin. Koi herpesvirus bilan bog‘liq kasallik 1998-yildan keyin Shimoliy Amerika, Yevropa va Osiyodagi karp va koi xo‘jaliklarida jiddiy yo‘qotishlar bilan bog‘langan. Shu sababli profilaktika, karantin va biologik xavfsizlik kasallikni davolashdan oldingi asosiy boshqaruv vositalaridan hisoblanadi.

6. Bioxavfsizlik va profilaktika

Karp xo‘jaligida bioxavfsizlikning birinchi bosqichi xo‘jalikka yangi baliq materialini nazorat ostida kiritishdir. Yangi olib kelingan baliqlarni alohida saqlash, kuzatish va zarur diagnostik tekshiruvlardan o‘tkazish xo‘jalikka patogenlarning kirib kelish xavfini kamaytiradi.

Asbob-uskunalarni suv havzalari o‘rtasida nazoratsiz ko‘chirish, kasal baliqlarni boshqa hovuzlarga o‘tkazish, o‘lik baliqlarni suv havzasida qoldirish va suv manbalarini nazoratsiz almashish epidemiologik xavfni oshirishi mumkin. Profilaktikaning maqsadi patogen mavjudligini butunlay yo‘qotish emas, balki uning xo‘jalik bo‘ylab tarqalishini cheklash va baliqning tabiiy qarshiligini saqlashdan iborat.

7. Reproduktiv material sifati va genetik boshqaruv

Karpning sun’iy ko‘paytirish texnologiyalari yaxshi rivojlangan bo‘lib, nazorat qilinadigan ko‘paytirish hatchery tizimlarida XX asrning o‘rtalaridan boshlab keng qo‘llanila boshlagan. Ilmiy sharhlarda karp spermatozoidlari chuchuk suvga chiqarilgandan keyin harakatchanlikka ega bo‘lishi va sun’iy urug‘lantirish texnologiyalari turning reproduktiv jarayonlarini boshqarish imkonini bergani ko‘rsatiladi.

Nasldor baliqlarni tanlashda faqat tana massasiga emas, balki kasalliklarga chidamlilik, tana shakli, o‘sish, yashovchanlik va reproduktiv ko‘rsatkichlarga ham e’tibor berish maqsadga muvofiq. Seleksiya bo‘yicha sharhlar karpda ayrim xo‘jalik belgilarini, jumladan kasallikka chidamlilik va tana shaklini tanlash imkoniyati mavjudligini ko‘rsatadi.

8. Sun’iy reproduksiya va genetik texnologiyalar

Karpda reproduktiv biotexnologiyalar rivojlanishi seleksiya dasturlarining samaradorligini oshirish imkonini beradi. Ilmiy adabiyotlarda ginogenez, androgenez, poliploidiya va bir jinsli avlod olish kabi xromosoma to‘plamini boshqarish texnologiyalari tasvirlangan. Bunday usullar asosan ilmiy va seleksion maqsadlarda qo‘llanadi va ularning amaliy samaradorligi texnologiya, nasl va xo‘jalik sharoitiga bog‘liq.

Karp genomikasi bo‘yicha tadqiqotlar ham sezilarli rivojlangan. Ilmiy manbalarda turning genom resurslari va genomik seleksiya uchun molekulyar vositalar ishlab chiqilgani qayd etiladi. Bu yo‘nalish kelajakda o‘sish, kasallikka chidamlilik va boshqa xo‘jalik belgilarini aniqroq tanlashga xizmat qilishi mumkin.

9. Barqaror karp akvakulturasi modeli

Barqaror ishlab chiqarish modelida uchta tizim birgalikda boshqarilishi lozim: oziqa oqimi, suv sifati va baliq sog‘lig‘i. Oziqa oqimi ortiqcha bo‘lsa, suvdagi organik yuklama oshadi; suv sifati yomonlashsa, stress va kasallik xavfi ortadi; kasalliklar kuchaysa, o‘sish va yemdan foydalanish samaradorligi pasayadi. Demak, bu uch omil o‘zaro bog‘langan boshqaruv tizimini tashkil qiladi.

Shu nuqtai nazardan, karp xo‘jaligida kunlik oziqlantirish jurnalini yuritish, biomassa o‘zgarishini davriy baholash, suv parametrlarini qayd etish, o‘lim holatlarini alohida hisobga olish va kasallik alomatlari paydo bo‘lganda tezkor diagnostika qilish ishlab chiqarishning nazorat qilinadiganligini oshiradi.

Xulosa

Karp akvakulturasida yuqori mahsuldorlikka erishish faqat baliq sonini yoki yem miqdorini oshirish bilan belgilanmaydi. Oziqlantirish strategiyasi suv sifati, baliq zichligi va sog‘liqni boshqarish bilan birgalikda olib borilgandagina biologik va iqtisodiy jihatdan barqaror natija olish mumkin.

Ilmiy manbalar karpning tabiiy oziqa resurslaridan foydalanish imkoniyati kengligini, sun’iy yemni o‘zlashtirish qobiliyatini va qulay sharoitlarda yuqori o‘sish sur’atlarini ko‘rsatadi. Shu bilan birga, kasalliklar bo‘yicha tadqiqotlar ekologik stress va xo‘jalikdagi noqulay sharoitlar kasallik xavfini kuchaytirishi mumkinligini ko‘rsatadi.

Shuning uchun O‘zbekiston sharoitidagi karp xo‘jaliklarida oziqlantirishni mahalliy suv harorati va tabiiy oziqa bazasiga moslashtirish, suv sifatini muntazam monitoring qilish, baliq zichligini hovuz imkoniyatlariga muvofiq belgilash, nasldor materialni nazorat qilish va bioxavfsizlik protokollarini joriy etish istiqbolli yo‘nalishlar hisoblanadi.

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MAKTABGACHA YOSHDAGI BOLALARGA HAYOT XAVFSIZLIGI QOIDALARINI O‘RGATISHNING NAZARIY ASOSLARI

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Annotatsiya

Ushbu maqolada maktabgacha yoshdagi bolalarga hayot xavfsizligi qoidarini o‘rgatishning zamonaviy pedagogik, psixologik va metodologik asoslari atroflicha tahlil qilingan. Maktabgacha ta’lim yoshidagi bolalarning fiziologik va psixologik rivojlanish xususiyatlari, ularning atrof-muhitni anglash darajasi hamda xavf-xatarlarga bo‘lgan reaksiyalari yoritilgan. Maqolada xavfsiz xulq-atvor ko‘nikmalarini shakllantirishning asosiy pedagogik prinsiplari, interfaol metodlar, muammoli vaziyatlarni modellashtirish hamda o‘yin texnologiyalarining samaradorligi ilmiy jihatdan asoslab berilgan. Shuningdek, maktabgacha ta’lim tashkilotlari va oila hamkorligining bolalar xavfsizligini ta’minlashdagi roli ochib berilgan.

Kalit so‘zlar: maktabgacha yosh, hayot xavfsizligi, xavfsiz xulq-atvor, pedagogik prinsiplar, o‘yin faoliyati, muammoli vaziyatlar, ijtimoiy moslashuv, sensor rivojlanish, shaxsiy namuna.

Abstract

This article provides a comprehensive analysis of the contemporary pedagogical, psychological, and methodological foundations of teaching the basics of life safety to preschool children. The physiological and psychological developmental characteristics of preschool-aged children, their level of environmental awareness, and their reactions to hazards are examined. The paper scientifically justifies the effectiveness of key pedagogical principles, interactive methods, problem situation modeling, and game technologies in shaping safe behavior skills. Furthermore, the role of collaboration between preschool education organizations and families in ensuring child safety is highlighted.

Keywords: preschool age, life safety, safe behavior, pedagogical principles, play activity, problem situations, social adaptation, sensory development, personal example.

KIRISH

Bugungi tezkor va jadal rivojlanayotgan, texnogen xavf-xatarlar kuchaygan davrda maktabgacha yoshdagi bolalarning hayoti va sog‘lig‘ini muhofaza qilish global miqyosdagi dolzarb muammolardan biridir. Maktabgacha yoshdagi bolalar tabiatan atrof-muhitni faol o‘rganishga intiluvchan bo‘lishadi, biroq ularning hayotiy tajribasining kamligi, jismoniy imkoniyatlarining cheklanganligi va analizatorlar tizimining to‘liq rivojlanmaganligi ularni xavf-xatarlar qarshisida ojiz qoldiradi.

O‘zbekiston Respublikasining Maktabgacha ta’lim sohasidagi davlat siyosati va “Ilk qadam” milliy o‘quv dasturi talablariga ko‘ra, bolalarni har tomonlama rivojlantirish bilan bir qatorda, ularda ijtimoiy moslashuv va xavfsiz hayot faoliyati ko‘nikmalarini shakllantirish ta’limning uzluksiz bo‘g‘ini sifatida belgilangan. Hozirgi davr pedagogikasi oldida bolani shunchaki taqiqlar bilan cheklash emas, balki ularda mustaqil va anglangan xavfsiz xulq-atvor madaniyatini shakllantirish vazifasi turibdi.

ADABIYOTLAR TAHLILI

Maktabgacha yoshdagi bolalarga xavfsizlik tushunchalarini singdirish muammosi uzoq yillardan buyon fundamental pedagogik va psixologik tadqiqotlar ob’ekti bo‘lib kelmoqda.

Jan Piaje o‘zining kognitiv rivojlanish konsepsiyasida maktabgacha yoshdagi bolalarning tafakkuri asosan ko‘rgazmali-obrazli va egotsentrik xarakterga ega ekanligini isbotlagan. Bu xususiyat bolaga abstrakt xavflarni idrok etishga yo‘l qo‘ymaydi, demak, ta’lim faqatgina sensor materiallarga tayanishi shart.

Lev Vygotskiy o‘zining “Yaqin rivojlanish zonasi” nazariyasida bolaning ijtimoiy tajriba va xavfsizlik qoidalarini o‘zlashtirishi bevosita kattalar (tarbiyachi va ota-onalar) bilan hamkorlikdagi intersub’ektiv muloqot jarayonida yuz berishini asoslagan.

Zamonaviy pedagog olimlardan N.N. Avdeyeva, O.L. Knyazeva, R.B. Sterkina maktabgacha yoshdagi bolalar uchun hayot xavfsizlik qoidalari tarkibini to‘rtta asosiy tizimga (uy, ko‘cha, tabiat, jamiyat) ajratgan holda o‘quv-metodik majmuasini yaratdilar.

Milliy pedagogikada F.R. Qodirova va Sh.M. Qodirova maktabgacha yoshdagi bolalarning xavfsiz faoliyatini milliy mentalitet, milliy o‘yinlar va ertaklar integratsiyasi orqali tashkil etish mexanizmlarini tadqiq etishgan.

TADQIQOT METODOLOGIYASI

Ushbu tadqiqot maktabgacha ta’lim tashkilotlarida bolalarga hayot xavfsizligini o‘rgatishning nazariy tizimlarini qiyosiy tahlil qilishga asoslangan. Metodologik asos sifatida tizimli-faoliyatli yondashuv (system-activity approach) va shaxsga yo‘naltirilgan ta’lim (person-centered education) prinsiplari olindi. Tadqiqot jarayonida maktabgacha yoshdagi bolalarning yosh fiziologiyasi, oliy asab faoliyati xususiyatlari hamda o‘yin motivatsiyasi qonuniyatlari umumlashtirildi.

TADQIQOT NATIJALARI VA MUHOKAMA

Nazariy tahlillar shuni ko‘rsatadiki, maktabgacha yoshdagi bolaga xavfsizlik qoidalarini quruq yodlatish amaliyotda kutilgan natijani bermaydi. Buning sababi bolaning oliy asab faoliyatidagi ikki xususiyatdir:

1. Ixtiyorsiz diqqatning ustunligi: Xavfli ob’ekt bolaning diqqatini jalb qiladi, biroq u xavfning intensivligini anglamaydi.

2. Hissiy reaktivlik: Kuchli qo‘rquv vaziyatida bolaning himoya reaksiyasi qochish yoki berkinish shaklida namoyon bo‘ladi, bu esa xavfni yanada oshiradi.

Maktabgacha ta’limda xavfsizlik ta’limining fundamental prinsiplari quyidagilardan iborat:

- Izchillik va tizimlilik: Bilimlarni soddadan murakkabga, elementardan global xavflarga qarab berish.
- Muqobillik (Qo‘rquvsizlik): Bolani qo‘rqitish emas, balki to‘g‘ri yechim va xavfsiz harakat algoritmini taklif qilish.
- Interaktivlik va Faoliyatlilik: Bolani ta’limning sub’ektiga aylantirish, qoidalarni o‘yin va harakat orqali o‘zlashtirish.
- Kontekstuallik (Hayotiylik): Bilimlarning bolaning kundalik hayoti va real hududi bilan bog‘liqligi.

Tadqiqot natijalariga ko‘ra, maktabgacha yoshdagi bolalarda xavfsiz xulq-atvorni shakllantirishning eng samarali metodologik vositasi — Muammoli vaziyatlarni modellashtirish (Situation modeling) hisoblanadi. Tarbiyachi tomonidan yaratilgan keyslar bolalarda tanqidiy fikrlash va refleksiyani uyg‘otadi. O‘yin texnologiyalari bolaga xavfsiz xatti-harakatlarni avtomatizm darajasiga yetkazishga yordam beradi. Xavfsiz xulq-atvor refleksiv xarakterga ega. Agar bog‘chada o‘rgatilgan svetofor qoidasi ko‘chada ota-ona tomonidan buzilsa, bolaning ongi ziddiyatga uchraydi. Shuning uchun ham ta’lim jarayoniga ota-onalarni integratsiya qilish, ularga hamkorlik klasteri asosida eslatmalar va seminar-treninglar taqdim etish tizimning ajralmas bo‘lagi bo‘lishi lozim.

XULOSA

Maktabgacha yoshdagi bolalarga hayot xavfsizligi asoslarini o‘rgatishning nazariy-metodologik asoslari shuni ko‘rsatadiki, samarali ta’lim quruq taqiqlardan voz kechib, bolaning faoliyatli hamda kognitiv imkoniyatlariga tayanishi zarur. Tizimli yo‘naltirilgan o‘yin metodlari, interaktiv keys-stadi hamda maktabgacha ta’lim tashkiloti va oilaning uzviy hamkorligi bolalarda barqaror xavfsiz xulq-atvor ko‘nikmalarini shakllantirishning bosh omilidir. Bu esa kelajakda jamiyat uchun har tomonlama sog‘lom, hushyor va mas’uliyatli shaxsni tarbiyalashga xizmat qiladi.

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O‘RTA ASRLAR KULOLCHILIK SAN’ATI VA UNING MUZEY KOLLEKSIYALARIDAGI NAMUNALARI

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Annotatsiya

Mazkur maqolada O‘rta Osiyo, xususan, Movarounnahr hududida o‘rta asrlar davrida rivojlangan kulolchilik san’ati, uning texnologik, badiiy va funksional xususiyatlari hamda muzey kolleksiyalarida saqlanayotgan moddiy madaniyat namunalari tarixiy-arxeologik nuqtayi nazardan tahlil qilinadi. Kulolchilik buyumlari o‘rta asrlar jamiyatining kundalik turmushi, hunarmandchilik darajasi, savdo-iqtisodiy aloqalari, estetik qarashlari va madaniy an’analarini o‘rganishda muhim moddiy manba hisoblanadi. Maqolada sopol idishlarning shakli, tayyorlanish texnologiyasi, sirlanish usullari, bezak motivlari va funksional xususiyatlari asosiy tadqiqot mezonlari sifatida belgilanadi. Shuningdek, Samarqand, Buxoro, Xorazm va boshqa tarixiy-madaniy hududlardan topilgan kulolchilik namunalarining muzeylashtirilishi, saqlanishi va ilmiy tadqiqotdagi ahamiyati yoritiladi. Tadqiqot natijasida muzey kolleksiyalaridagi kulolchilik buyumlari nafaqat san’at asari, balki o‘rta asrlar tarixini rekonstruksiya qilish imkonini beruvchi kompleks moddiy manba ekanligi asoslanadi.

Kalit so‘zlar: o‘rta asrlar, kulolchilik, keramika, sirlangan keramika, sopol idishlar, moddiy madaniyat, arxeologik topilmalar, muzey eksponatlari, Movarounnahr, Samarqand, Buxoro, Xorazm.

Kirish

O‘rta asrlar Markaziy Osiyo tarixida shahar madaniyati, hunarmandchilik, savdo-sotiq va amaliy san’atning jadal rivojlangan davrlaridan biri hisoblanadi. Ushbu jarayonlarda kulolchilik alohida o‘rin egallagan. Chunki sopol buyumlar kundalik hayotning deyarli barcha jabhalarida — oziq-ovqat va suv saqlash, ovqat tayyorlash va iste’mol qilish, xo‘jalik faoliyati, qurilish hamda marosimlarda keng qo‘llanilgan.

Kulolchilik mahsulotlarining arxeologik qazishmalar jarayonida ko‘p miqdorda uchrashi ularni tarixiy tadqiqotlar uchun nihoyatda muhim manbaga aylantiradi. Arxeologik yodgorliklarning madaniy qatlamlaridan topilgan sopol buyumlar orqali muayyan hududning xo‘jalik hayoti, ishlab chiqarish texnologiyasi, savdo aloqalari va estetik qarashlari haqida ma’lumot olish mumkin. Arxeologiyada keramika ko‘pincha davrlashtirish va madaniy qatlamlarni aniqlashda ham muhim mezonlardan biri sifatida qo‘llanadi[1].

O‘zbekiston hududida, ayniqsa Samarqand, Buxoro, Xorazm, Farg‘ona vodiysi va boshqa tarixiy-madaniy markazlarda kulolchilikning turli shakllari shakllangan. Samarqandning Afrosiyob hududidan topilgan sirlangan keramika namunalari o‘rta asrlar davrida kulolchilik texnologiyasi va badiiy bezakning yuqori darajada rivojlanganidan dalolat beradi. X–XII asrlarga oid ayrim sirlangan idishlarda epigrafik bezaklarning qo‘llanilishi ham kulolchilikni faqat maishiy hunar emas, balki badiiy tafakkur mahsuli sifatida ko‘rsatadi.

Mavzuning dolzarbligi shundaki, muzeylarda saqlanayotgan kulolchilik namunalari arxeologik topilmalarni faqat ekspozitsiya obyekti sifatida emas, balki tarixiy jarayonlarni o‘rganishning muhim moddiy manbasi sifatida qayta ko‘rib chiqish imkonini beradi. O‘zbekiston muzeylarining arxeologiya fondlarida sopol buyumlar, tangalar, muhrlar, taqinchoqlar va boshqa moddiy madaniyat namunalari bilan bir qatorda kulolchilik buyumlari ham muhim o‘rin tutadi. Masalan, Buxoro hududidagi arxeologik tadqiqotlardan topilgan ko‘plab moddiy namunalar muzey fondlariga topshirilib, ularning bir qismi ekspozitsiyalardan o‘rin olgan [2].

Tadqiqotning asosiy maqsadi — o‘rta asrlar kulolchilik san’atining asosiy rivojlanish xususiyatlarini aniqlash, muzey kolleksiyalaridagi keramika namunalarining tarixiy-madaniy ahamiyatini ochib berish hamda ularni moddiy manba sifatida ilmiy baholashdan iborat.

Tadqiqot vazifalari quyidagilardan iborat: o‘rta asrlar kulolchilik san’atining rivojlanish bosqichlarini tavsiflash;

kulolchilik buyumlarining asosiy shakl va turlarini aniqlash;

sopol idishlarni tayyorlash va bezash texnologiyalarini tahlil qilish;

sirlangan keramikaning badiiy xususiyatlarini ko‘rsatish;

muzey kolleksiyalaridagi kulolchilik namunalarining tarixiy qiymatini aniqlash; keramika buyumlarini tarixiy-arxeologik manba sifatida baholash.

Adabiyotlar tahlili va metodologiyasi: O‘rta Osiyo kulolchilik san’atini o‘rganish tarix, arxeologiya, san’atshunoslik va etnografiya fanlarining kesishgan nuqtasida shakllangan. Mazkur yo‘nalishdagi tadqiqotlarni shartli ravishda bir necha guruhga ajratish mumkin: hunarmandchilik tarixiga bag‘ishlangan tadqiqotlar, arxeologik keramika bo‘yicha ilmiy ishlar, kulolchilik texnologiyasi va badiiy bezaklarini o‘rganuvchi san’atshunoslik tadqiqotlari hamda muzey kolleksiyalarini tavsiflovchi katalog va ilmiy nashrlar.

R.G. Mukminovaning Samarqand va Buxorodagi hunarmandchilik tarixiga bag‘ishlangan monografiyasi mazkur masalani o‘rganishda muhim ilmiy manbalardan biridir. Muallifning 1976-yilda Toshkentda nashr etilgan tadqiqoti XVI asrda Samarqand va Buxoroda hunarmandchilikning tashkil etilishi, ishlab chiqarish jarayonlari va hunarmandlarning ijtimoiy-iqtisodiy hayotdagi o‘rnini tahlil qilishga qaratilgan. Asarda kulolchilik ham hunarmandchilikning muhim yo‘nalishlaridan biri sifatida qaraladi [3].

D.K. Mirzaahmedovning tadqiqotlari esa Buxoro kulolchiligini, ayniqsa sirlangan keramikaning tarixiy manba sifatidagi imkoniyatlarini o‘rganishda alohida ahamiyatga ega. Uning Buxoroning sirlangan keramika an’analariga bag‘ishlangan ilmiy ishlari keramika buyumlarining nafaqat badiiy, balki tarixiy manba sifatidagi qiymatini ko‘rsatadi. Muallifning 1987-yilda Samarqandda himoya qilingan avtoreferati Buxoroning sirlangan keramika namunalarini tarixiy manba sifatida tahlil qilishga bag‘ishlangan.

“История материальной культуры Узбекистана” turkumidagi nashrlar O‘zbekiston hududidan topilgan moddiy madaniyat namunalarini ilmiy muomalaga kiritishda muhim rol o‘ynagan. Ushbu nashrlarda keramika, shisha, metall buyumlar va boshqa arxeologik materiallar bo‘yicha tadqiqotlar e’lon qilingan.

Zamonaviy tadqiqotlarda keramikaning badiiy xususiyatlariga ham katta e’tibor berilmoqda. Xususan, O‘zbekiston sirlangan keramika san’atining shakllanishida islomiy estetik qarashlarning o‘rni, epigrafik va geometrik bezaklarning rivojlanishi hamda Afrosiyob, Buxoro, Shosh, Farg‘ona, Chag‘oniyon, Xorazm kabi markazlar o‘rtasidagi uslubiy aloqalar tahlil qilinmoqda [4].

Adabiyotlar tahlili shuni ko‘rsatadiki, mavjud tadqiqotlarda kulolchilikning texnologik, tarixiy va badiiy jihatlari alohida-alohida o‘rganilgan. Biroq arxeologik topilmalarni bevosita muzey kolleksiyalari bilan bog‘lab, ularni bir vaqtning o‘zida tarixiy, san’atshunoslik va muzeyshunoslik nuqtayi nazaridan kompleks tahlil qilish masalasi yanada chuqur tadqiq etishni talab qiladi.

Tadqiqotda tarixiylik, xolislik va tizimlilik tamoyillariga asoslanildi. Kulolchilik namunalarini o‘rganishda tarixiy-qiyosiy, tipologik, texnologik, formal-badiiy va manbashunoslik usullaridan foydalanildi.

Tarixiy-qiyosiy metod orqali turli davr va hududlarga oid kulolchilik namunalarining o‘xshash va farqli jihatlari aniqlanadi. Bu usul Samarqand, Buxoro, Xorazm va boshqa markazlarning keramika an’analarini qiyosiy o‘rganish imkonini beradi.

Tipologik metod sopol buyumlarni shakli, vazifasi, o‘lchami va konstruktiv tuzilishiga ko‘ra guruhlarga ajratishga xizmat qiladi. Bunda kosa, piyola, lagan, ko‘za, xum, xurmacha va boshqa idish turlari alohida ko‘rib chiqiladi.

Texnologik metod orqali loyni tayyorlash, shakl berish, pishirish, sir bilan qoplash va bezash jarayonlari tahlil qilinadi.

Formal-badiiy tahlil idishlarning kompozitsiyasi, ranglari, naqshlari, geometrik va o‘simliksimon motivlari, epigrafik bezaklari hamda tasviriy elementlarini o‘rganishni nazarda tutadi.

Muzeyshunoslik metodi eksponatning kelib chiqishi, topilgan joyi, saqlanish holati, ilmiy tavsifi, ekspozitsiyadagi o‘rni va tarixiy ahamiyatini baholashda qo‘llanildi.

Tadqiqotning manbashunoslik bazasini arxeologik qazishmalar materiallari, ilmiy monografiyalar, maqolalar, muzey kolleksiyalari haqidagi ma’lumotlar hamda moddiy madaniyatga oid ilmiy nashrlar tashkil etadi. O‘zbekistonda arxeologik tadqiqotlarning institutsional bazasi ham shakllangan bo‘lib, Yahyo G‘ulomov nomidagi Arxeologiya instituti O‘zbekiston hududidagi arxeologik merosni ilmiy o‘rganishda muhim ilmiy markazlardan biridir [5].

O‘rta asrlarda kulolchilik san’atining rivojlanishi

Kulolchilik insoniyatning eng qadimgi hunarmandchilik turlaridan biri bo‘lib, loydan idishlar tayyorlash texnologiyasi juda qadimiy davrlarga borib taqaladi. Kulolchilik charxining rivojlanishi esa buyumlarni standart shaklda va yuqori sifatda tayyorlash imkoniyatlarini kengaytirgan. O‘zbekiston kulolchilik tarixiga oid o‘quv va ilmiy manbalarda kulolchilikning uzoq tarixiy taraqqiyot yo‘li, sopol va keramika mahsulotlarining turlari hamda ularning ishlab chiqarish texnologiyasi haqida ma’lumotlar beriladi[6].

O‘rta asrlar davriga kelib, Markaziy Osiyo shaharlarida hunarmandchilik ishlab chiqarishi sezilarli darajada takomillashdi. Shaharlarning iqtisodiy va madaniy markaz sifatida rivojlanishi kulolchilik mahsulotlariga bo‘lgan talabni oshirdi. Natijada kulollar tomonidan turli maqsadlarga mo‘ljallangan idishlar ishlab chiqarila boshlandi.

Kulolchilik mahsulotlarini shartli ravishda quyidagi guruhlarga ajratish mumkin:

1. **Maishiy idishlar** — kosa, piyola, lagan, tovoq, ko‘za va xurmachalar.
2. **Xo‘jalik idishlari** — xum, katta ko‘za va oziq-ovqat saqlashga mo‘ljallangan boshqa buyumlar.
3. **Maxsus vazifali buyumlar** — xo‘jalik, hunarmandchilik yoki marosimlarda foydalanilgan idishlar.
4. **Me’moriy keramika** — koshin, bezak plitalari va qurilishda ishlatilgan sopol elementlar.

Ularning shakli va bezagi jamiyatning estetik qarashlari bilan bir qatorda, amaliy ehtiyojlarini ham aks ettirgan.

Sirlangan keramika va badiiy bezak

O‘rta asrlar kulolchiligida eng muhim texnologik yangiliklardan biri sirlangan keramikaning keng rivojlanishidir. Sir buyum yuzasini himoya qilish bilan birga unga rang, yaltiroqlik va dekorativ joziba bergan. Natijada oddiy maishiy idish badiiy qiymatga ega buyumga aylangan.

Samarqandning Afrosiyob hududidan topilgan keramika namunalari bu borada alohida ahamiyatga ega. X–XII asrlarga oid ayrim sirlangan idishlarda yozuvli bezaklarning qo‘llanilishi kulolchilik bilan xattotlik va bezak san’atining o‘zaro uyg‘unlashganini ko‘rsatadi. Afrosiyob keramika an’analari Buxoro, Shosh, Farg‘ona, Chag‘oniyon, Merv va Xorazm kabi hududlarning keramika madaniyati bilan umumiy uslubiy xususiyatlarga ega bo‘lgan [7].

Keramika bezaklarida geometrik shakllar, o‘simliksimon naqshlar, epigrafik yozuvlar va ayrim hollarda ramziy tasvirlar qo‘llangan. Bezakning mazmuni va shakli nafaqat ustaning mahoratini, balki o‘sha davrning estetik va madaniy qarashlarini ham aks ettirgan.

Sirlangan keramikaning rivojlanishi kulolchilik ishlab chiqarishining texnik imkoniyatlari kengayganidan dalolat beradi. Bunday buyumlar oddiy ehtiyojni qondirish vositasi bo‘lish bilan birga, savdo va madaniy almashinuv jarayonlarining ham mahsuliga aylangan.

Muzey kolleksiyalaridagi kulolchilik namunalari

Muzey kolleksiyalarida saqlanayotgan kulolchilik buyumlari arxeologik qazishmalar natijasida aniqlangan tarixiy jarayonlarni ko‘rgazmali shaklda namoyish etish imkonini beradi. Muzey eksponatining asosiy qiymati uning tashqi ko‘rinishidagina emas, balki kelib chiqishi, topilgan arxeologik konteksti, sanasi, ishlab chiqarish texnologiyasi va tarixiy vazifasi bilan belgilanadi.

Buxoro hududida olib borilgan arxeologik tadqiqotlar natijasida topilgan sopol buyumlarning bir qismi Buxoro davlat muzey-qo‘riqxonasi arxeologiya fondiga topshirilgani haqida manbalarda ma’lumotlar mavjud. Mazkur fondlarda sopol buyumlar bilan bir qatorda haykalchalar, tangalar, muhrlar, taqinchoqlar va boshqa arxeologik topilmalar ham saqlanadi [8].

Muzeydagi keramika namunasini ilmiy jihatdan tavsiflashda quyidagi ko‘rsatkichlar muhim:

eksponatning nomi;
topilgan hududi;
arxeologik yodgorlik nomi;
taxminiy sanasi;
materiali;
tayyorlash texnologiyasi;
shakli;
o‘lchamlari;
bezak turi;

sirlangan yoki sirsizligi;
saqlanish holati;
restavratsiya qilingan-qilinmaganligi;
muzey fondidagi inventar raqami.

Bunday kompleks tavsif eksponatni oddiy “sopol idish” sifatida emas, balki muayyan tarixiy davr va ijtimoiy-madaniy muhitni ifodalovchi manba sifatida o‘rganish imkonini beradi.

Natija va muhokamalar

Tadqiqot natijasida o‘rta asrlar kulolchilik san’ati bo‘yicha bir qator ilmiy xulosalarga kelish mumkin.

Birinchidan, kulolchilik o‘rta asrlar jamiyatining kundalik hayoti bilan bevosita bog‘liq bo‘lgan va shu sababli uning moddiy madaniyatini o‘rganish uchun keng imkoniyat beruvchi manbadir.

Ikkinchidan, keramika shakllari va texnologiyasidagi o‘zgarishlar jamiyatning iqtisodiy va texnik taraqqiyoti bilan chambarchas bog‘liq bo‘lgan. Kulolchilik charxidan foydalanish, pishirish texnologiyasining takomillashishi va sirlangan buyumlarning ko‘payishi ishlab chiqarish imkoniyatlarining kengayganini ko‘rsatadi.

Uchinchidan, o‘rta asrlar keramika bezaklari o‘sha davr badiiy tafakkurining muhim ko‘rinishlaridan biridir. Geometrik, o‘simliksimon va epigrafik naqshlarning qo‘llanilishi kulolchilikning amaliy san’at bilan chambarchas bog‘langanini ko‘rsatadi.

To‘rtinchidan, muzey kolleksiyalaridagi keramika namunalarini arxeologik kontekst bilan birgalikda o‘rganish ularning ilmiy qiymatini sezilarli darajada oshiradi.

Beshinchidan, Samarqand, Buxoro va boshqa markazlarning kulolchilik mahsulotlaridagi umumiy va farqli xususiyatlar hududlararo madaniy aloqalarni o‘rganish uchun muhim material beradi. Ayniqsa, sirlangan keramika uslublarining turli hududlarda tarqalishi madaniy va iqtisodiy aloqalarning mavjudligini ko‘rsatishi mumkin [9].

Kulolchilik buyumlarining tarixiy qiymatini baholashda faqat ularning badiiy ko‘rinishiga e’tibor qaratish yetarli emas. Eksponatning tarixiy ahamiyati uning topilgan joyi va arxeologik qatlamdagi o‘rniga ham bog‘liq. Bir xil shakldagi yoki o‘xshash bezakli idishlar turli hududlarda uchrashi mumkin, biroq ularning xronologiyasi, mahalliy ishlab chiqarish an’analari va savdo yo‘llari bilan aloqasi turlicha bo‘lishi ehtimoldan xoli emas.

Shu nuqtayi nazardan muzey kolleksiyalaridagi keramika buyumlarini uch darajada o‘rganish maqsadga muvofiq:

Birinchi daraja — predmetshunoslik tahlili. Bunda idishning shakli, materiali, o‘lchami, texnologiyasi va bezagi o‘rganiladi.

Ikkinchi daraja — tarixiy-arxeologik tahlil. Buyumning topilgan joyi, madaniy qatlami, sanasi va boshqa topilmalar bilan aloqasi aniqlanadi.

Uchinchi daraja — tarixiy-madaniy talqin. Buyum orqali o‘sha davrning turmush tarzi, estetik qarashlari, hunarmandchilik an’analari va savdo-madaniy aloqalari qayta tiklanadi.

Bunday yondashuv muzey eksponatlarini statik obyekt sifatida emas, balki tarixiy jarayonning moddiy dalili sifatida talqin qilish imkonini beradi.

Mavjud ilmiy adabiyotlar ham kulolchilikni hunarmandchilik tarixi bilan bog‘liq holda o‘rganish zarurligini ko‘rsatadi. R.G. Mukminovaning tadqiqotlari Samarqand va Buxoro hunarmandchiligining ijtimoiy-iqtisodiy ahamiyatini ochib bersa, D.K. Mirzaahmedovning ishlari keramikaning tarixiy manba sifatidagi imkoniyatlarini chuqurlashtiradi [10].

Shu bilan birga, zamonaviy muzeyshunoslik nuqtayi nazaridan eksponatning ilmiy pasportini mukammallashtirish, raqamlashtirish, 3D tasvirlarini yaratish, kelib chiqish tarixini elektron bazaga kiritish va turli muzey kolleksiyalarini o‘zaro taqqoslash istiqbolli yo‘nalishlardan hisoblanadi.

Xulosa

O‘rta asrlar kulolchilik san’ati Markaziy Osiyo, xususan, Movarounnahr moddiy va badiiy madaniyatining muhim tarkibiy qismi hisoblanadi. Kulolchilik buyumlari o‘rta asrlar kishilarining kundalik turmushi, xo‘jalik faoliyati, hunarmandchilik mahorati, estetik qarashlari va madaniy aloqalari haqida qimmatli ma’lumot beradi.

Tadqiqot shuni ko‘rsatadiki, sopol buyumlarning tarixiy qiymati ularning tashqi ko‘rinishi bilangina belgilanmaydi. Ularning shakli, ishlab chiqarish texnologiyasi, sirlanishi, bezaklari, topilgan arxeologik muhiti va muzeyda saqlanish tarixi o‘zaro birgalikda tahlil qilingandagina to‘liq ilmiy xulosa chiqarish mumkin.

Samarqand-Afrosiyob, Buxoro va boshqa tarixiy markazlardan topilgan keramika namunalari o‘rta asrlar kulolchilik san’atining texnologik va badiiy jihatdan yuqori darajada rivojlanganini ko‘rsatadi. Xususan, sirlangan keramika va epigrafik bezaklarning rivojlanishi kulolchilikning amaliy ehtiyojdan tashqari estetik va ramziy funksiyaga ham ega bo‘lganini ko‘rsatadi.

Muzey kolleksiyalaridagi kulolchilik eksponatlari esa arxeologik topilmalarni kelajak avlodga yetkazish, ularni ilmiy muomalaga kiritish va tarixiy xotirani shakllantirishda katta ahamiyatga ega. Shu sababli muzeylardagi keramika kolleksiyalarini tizimli kataloglashtirish, ilmiy pasportlashtirish, raqamlashtirish va hududlar kesimida qiyosiy o‘rganish kelgusidagi tadqiqotlarning muhim yo‘nalishlaridan biri bo‘lishi lozim.

Umuman olganda, o‘rta asrlar kulolchilik namunalarini muzey eksponatlari bilan bog‘liq holda tadqiq etish tarix, arxeologiya, san’atshunoslik va muzeyshunoslik fanlari o‘rtasidagi ilmiy aloqalarni kuchaytiradi hamda O‘zbekistonning boy moddiy-madaniy merosini yanada chuqurroq anglash imkonini beradi.

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THE EVOLUTION OF COMMUNICATIVE COMPETENCE MODELS AND THEIR IMPLICATIONS FOR EFL TEACHING IN UZBEKISTAN: FROM CANALE AND SWAIN TO BACHMAN

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Abstract

This article traces how the concept of communicative competence developed from Hymes's sociolinguistic critique of Chomsky to the componential models of Canale and Swain (1980), Canale (1983) and Bachman (1990), and examines what these models mean for teaching English as a foreign language (EFL) in Uzbekistan. The study uses a qualitative comparative-analytical review of foundational theoretical works, the Common European Framework of Reference (CEFR) and its 2020 Companion Volume, and the national regulatory documents that introduced CEFR-aligned standards in Uzbekistan. The results show that the models differ mainly in how they organise knowledge (grammatical, discourse, sociolinguistic) and in how they treat strategic competence: as a compensatory skill in Canale and Swain, and as a central metacognitive capacity in Bachman. The comparison indicates that Uzbek EFL classrooms, historically shaped by grammar-translation practice, tend to develop grammatical competence more than discourse, sociolinguistic and strategic competence. The article proposes a component-based framework for lesson design and assessment in which each competence is linked to concrete classroom tasks and CEFR descriptors. The framework also serves as a theoretical basis for evaluating digital and artificial intelligence (AI) tools in later stages of research.

Keywords: communicative competence; Canale and Swain; Bachman; communicative language ability; strategic competence; CEFR; EFL; Uzbekistan.

Introduction

Over the past decade, English language teaching in Uzbekistan has moved from a knowledge-centred tradition towards a competence-based paradigm. The turning point was Presidential Decree No. PQ-1875 of 10 December 2012, "On measures to further improve the system of learning foreign languages", which introduced foreign language instruction from the first grade and required the use of modern communicative methods. In 2013, the Cabinet of Ministers approved state educational standards for foreign languages aligned with the Common European Framework of Reference (CEFR), setting target levels from A1 in primary school to C1 for language majors. Presidential Resolution No. PQ-5117 of 19 May 2021 further expanded this policy by encouraging the popularisation of foreign languages and strengthening teacher certification.

These reforms share one central goal: learners should be able to use English for real communication, not only reproduce grammatical rules. In applied linguistics, this goal is expressed by the concept of **communicative competence**. However, the term is often used in Uzbek methodological literature and teacher training without a clear explanation of which model it refers to and which components it includes. As a result, teachers may declare a communicative aim while continuing to assess mainly grammatical accuracy and vocabulary recall. Hasanova (2007) described this tension between declared reform and grammar-translation practice in Uzbek classrooms, and the gap between policy and practice remains an important research problem.

The concept itself has a long history. Chomsky (1965) distinguished linguistic *competence* (an ideal speaker's knowledge of grammar) from *performance*. Hymes (1972) argued that this view ignored the social rules of language

use and proposed "communicative competence" as knowledge of both grammar and appropriateness. Canale and Swain (1980) turned this idea into a model for second language teaching and testing, which Canale (1983) later extended. Bachman (1990) and Bachman and Palmer (1996) then developed the more detailed model of communicative language ability (CLA), which strongly influenced language testing and the CEFR.

The **aim** of this article is to compare these models systematically and to show how their components can be applied in EFL teaching in Uzbekistan. The study addresses three research questions:

1. How did the components of communicative competence change from Canale and Swain (1980) to Bachman (1990) and Bachman and Palmer (1996)?
2. What are the main theoretical differences between the models, especially regarding strategic competence?
3. How can these models guide lesson design and assessment in CEFR-aligned EFL instruction in Uzbekistan?

The article also forms the theoretical foundation of a broader study on AI-based pedagogical approaches: before digital tools can be judged as effective, it must be clear which component of communicative competence they are expected to develop.

Methods

The study employs a **qualitative comparative-analytical review**, a type of integrative literature review recommended when the goal is to critically synthesise theoretical frameworks rather than to aggregate statistical effects (Snyder, 2019).

1. Corpus of sources. Sources were selected in three groups:

• *Foundational theoretical works:* Chomsky (1965), Hymes (1972), Canale and Swain (1980), Canale (1983), Savignon (1983), Bachman (1990), Bachman and Palmer (1996), Celce-Murcia, Dörnyei and Thurrell (1995) and Celce-Murcia (2007).

• *Framework documents:* the CEFR (Council of Europe, 2001) and the CEFR Companion Volume (Council of Europe, 2020).

• *National documents and studies on Uzbekistan:* PQ-1875 (2012), the CEFR-aligned state educational standards (2013), PQ-5117 (2021), and research on English teaching in Uzbekistan (Hasanova, 2007; Jalolov, 2012).

2. Inclusion criteria. A source was included if it (a) proposed or critically revised a model of communicative competence, (b) was widely cited in applied linguistics or language testing, or (c) regulated or described EFL teaching in Uzbekistan.

2.3. Analytical procedure. The analysis was carried out in four steps:

1. *Extraction* — the components and sub-components of each model were identified and defined.
2. *Comparison* — the models were compared on five criteria: number of components, treatment of strategic competence, treatment of discourse/textual knowledge, orientation (teaching or testing), and link to CEFR.
3. *Mapping* — each component was matched with CEFR 2020 descriptor scales (linguistic, sociolinguistic and pragmatic competences) and with typical tasks in Uzbek EFL classrooms.
4. *Synthesis* — a component-based framework for lesson design and assessment was formulated.

2.4. Limitations. Because the study is theoretical, it does not measure learners' competence levels empirically. Its conclusions about classroom practice are analytical and should be tested in future experimental research.

Results

1. Evolution of the concept

The analysis shows a clear line of development: each model kept the core of the previous one and added a component that the earlier model had left implicit. Table 1 summarises this sequence.

Table 1.

Chronology of the main models of communicative competence

Year	Author(s)	Model / key idea	Components
1965	Chomsky	Competence vs performance	Grammatical knowledge of an ideal speaker-listener

1972	Hymes	Communicative competence	Whether an utterance is possible, feasible, appropriate and actually performed
1980	Canale & Swain	First model for L2 teaching and testing	Grammatical, sociolinguistic, strategic
1983	Canale	Extended model	Grammatical, sociolinguistic, discourse, strategic
1990	Bachman	Communicative language ability (CLA)	Language competence (organizational, pragmatic), strategic competence, psychophysiological mechanisms
1995	Celce-Murcia, Dörnyei & Thurrell	Pedagogically motivated model	Discourse, linguistic, actional, sociocultural, strategic
1996	Bachman & Palmer	Language knowledge + strategic competence	Organizational (grammatical, textual), pragmatic (functional, sociolinguistic), metacognitive strategies
2001 / 2020	Council of Europe	CEFR communicative language competences	Linguistic, sociolinguistic, pragmatic

2. The Canale and Swain model

Canale and Swain (1980) defined communicative competence as the underlying system of knowledge and skill required for communication. Canale (1983) separated discourse competence from sociolinguistic competence, producing the four-component model that is still most frequently cited in teacher education. Table 2 presents each component with an example of how it can be developed in an Uzbek EFL lesson.

Table 2.

Components of the Canale and Swain (1980) / Canale (1983) model and classroom applications

Component	Definition	Example task in the Uzbek EFL classroom
Grammatical	Knowledge of vocabulary, word formation, sentence structure, pronunciation and spelling	Practising the past simple by retelling how the family celebrated Navruz
Sociolinguistic	Producing and understanding utterances appropriate to the context, status of participants and purpose	Writing two emails on the same topic: to a university lecturer and to a friend
Discourse	Combining forms and meanings into a unified, coherent and cohesive text	Reordering jumbled paragraphs; linking ideas in an argumentative essay
Strategic	Verbal and non-verbal strategies used to compensate for breakdowns and to enhance communication	Information-gap tasks that require paraphrase, circumlocution and clarification requests

In this model, strategic competence is mainly **compensatory**: it becomes active when the speaker lacks a word or a structure. The components are listed side by side, and the model does not explain how they interact during real communication.

3. Bachman's model of communicative language ability

Bachman (1990) reorganised the components into a hierarchy (Figure 1). Grammatical and textual knowledge form *organizational competence*; illocutionary and sociolinguistic knowledge form *pragmatic competence*. The most important change concerns strategic competence, which becomes a separate capacity that links language knowledge to the context of use.

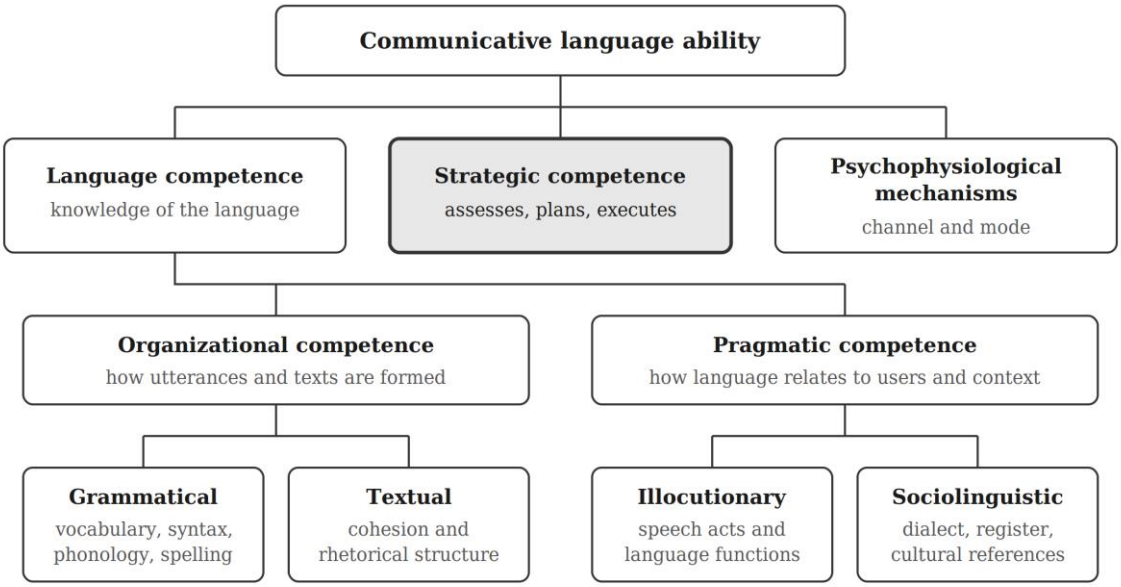


Figure 1. ***Components of communicative language ability (based on Bachman, 1990; Bachman & Palmer, 1996). Bachman and Palmer (1996) later renamed illocutionary competence functional knowledge.***

In Bachman's model, strategic competence operates in every act of communication, not only when problems occur. It assesses the situation, plans the utterance and controls its execution. Bachman and Palmer (1996) described it as a set of metacognitive strategies: goal setting, assessment and planning.

4. Comparison of the models

Table 3 compares the models on the five criteria defined in the Methods section.

Table 3.

Comparative analysis of communicative competence models

Criterion	Canale & Swain (1980) / Canale (1983)	Bachman (1990) / Bachman & Palmer (1996)	Celce-Murcia et al. (1995)	CEFR (2001 / 2020)
Main components	3, later 4	Language knowledge (2 areas) + strategic competence	5	3 communicative language competences
Strategic competence	Compensatory: repairs breakdowns	Metacognitive: governs all language use	Compensatory and enhancing	Part of communicative strategies (reception, production, interaction, mediation)
Discourse / text	Separate component (1983)	Textual competence inside organizational competence	Central component	Discourse competence inside pragmatic competence
Pragmatics	Included in sociolinguistic competence	Separate pragmatic competence	Actional competence	Pragmatic competence (discourse, functional)
Main purpose	Teaching and testing	Test design and validation	Syllabus design	Curriculum, teaching and assessment
Relations between components	Additive list	Hierarchical and interactive	Interactive, discourse at the centre	Illustrative descriptor scales by level

5. Mapping to EFL teaching in Uzbekistan

When the components are matched with CEFR 2020 descriptor scales and with the teaching practices described in the literature on Uzbekistan (Hasanova, 2007; Jalolov, 2012), an imbalance appears. Table 4 summarises this analytical mapping; it describes tendencies reported in the literature rather than measured levels.

Table 4.

Components of communicative competence in CEFR 2020 and in Uzbek EFL practice (analytical synthesis)

Component	Relevant CEFR 2020 scales	Typical classroom emphasis	Main gap
Grammatical / linguistic	Vocabulary range, grammatical accuracy, phonological control	Strong: rule explanation, translation, test drills	Fluency and pronunciation receive less practice
Discourse / textual	Thematic development, coherence and cohesion	Moderate: essay templates for examinations	Extended oral discourse is rarely practised
Sociolinguistic	Sociolinguistic appropriateness	Weak: textbook dialogues, limited authentic input	Register and politeness norms are not taught explicitly
Strategic	Communication strategies, mediation	Weak: errors are corrected immediately	Learners avoid speaking instead of using compensation strategies

6. A component-based framework for lesson design

Based on the comparison, the study proposes a framework in which every lesson stage targets a named component and uses a matching form of assessment (Table 5).

Table 5.

Component-based framework for a communicative EFL lesson

Lesson stage	Target component	Sample activity	Assessment
Lead-in	Sociolinguistic	Comparing greetings and forms of address in Uzbek and English	Teacher observation
Input	Discourse	Analysing how an authentic text is organised	Text-structure worksheet
Focused practice	Grammatical	Form-focused tasks in a meaningful context	Accuracy check, peer correction
Communicative task	Strategic	Information-gap or problem-solving task	Checklist of strategies used
Reflection	All components	Learner self-assessment against CEFR can-do statements	Self-assessment grid

Discussion

The first research question concerned the evolution of components. The results confirm that the development from Canale and Swain to Bachman was not a replacement of one model by another but a gradual refinement. Canale (1983) made discourse competence visible; Bachman (1990) grouped the knowledge components into organizational and pragmatic areas and explained how they interact. This agrees with Celce-Murcia's (2007) view that later models mainly clarify relationships between components rather than add entirely new knowledge.

The second research question concerned strategic competence, and here the difference is most significant for teaching. If strategic competence is only compensatory, as in Canale and Swain (1980), teachers may treat it as a "repair kit" for weak learners. If it is metacognitive, as in Bachman (1990), it becomes the capacity that turns knowledge into

performance for every learner. For Uzbek classrooms, the second interpretation has an important consequence: planning an utterance, monitoring it and adjusting it to the listener must be taught explicitly, not left to chance. Pre-task planning time, self-monitoring checklists and reflection on how a task was completed are practical ways of doing this.

The third research question concerned application in Uzbekistan. The mapping in Table 4 suggests that classroom practice still concentrates on the grammatical component, the one that is easiest to explain and to test. Several factors support this tendency: the grammar-translation tradition inherited from earlier decades (Hasanova, 2007), large class sizes, limited contact with native or proficient speakers outside the classroom, and examinations that historically rewarded accuracy over fluency. The adoption of CEFR-aligned standards in 2013 changed the declared goals, but the components defined in the models must also be reflected in textbooks, lesson plans and assessment tools. Otherwise, "communicative competence" remains a slogan rather than a measurable outcome.

The sociolinguistic component deserves special attention in the Uzbek context. Uzbek communicative culture places strong emphasis on respect for age and status, expressed through forms of address and indirectness. These norms can transfer into English and create unintended effects, for example, overly formal emails or an unwillingness to disagree openly in academic discussion. Explicit comparison of Uzbek and English norms, as suggested in Table 5, turns this potential interference into a resource for intercultural awareness, in line with Byram's (1997) concept of intercultural communicative competence.

The analysis has **implications for digital and AI-based teaching**, which is the focus of the broader research project. Most digital tools support the grammatical component well: automated feedback on grammar, spelling and vocabulary is now widely available. Fewer tools directly support discourse, sociolinguistic and strategic competence. Therefore, when a new tool is introduced, teachers and researchers should ask which component it develops and which component still requires human guidance. The component-based framework in Table 5 can be used as such an evaluation checklist.

The study has limitations. It is a theoretical review, and the mapping to Uzbek practice relies on published descriptions rather than classroom observation or testing. Future research should measure the four components separately in Uzbek learners, for example with speaking tasks rated on CEFR 2020 scales, and test whether component-based lesson design leads to more balanced development.

Conclusion

The study compared the main models of communicative competence and examined their relevance for EFL teaching in Uzbekistan. Three conclusions can be drawn.

1. The concept developed from Hymes's idea of appropriateness to the componential models of Canale and Swain (1980) and Canale (1983), and then to Bachman's (1990) hierarchical model of communicative language ability, which also underlies the CEFR.
2. The key theoretical difference lies in strategic competence: compensatory in Canale and Swain, metacognitive and central in Bachman. The metacognitive view is more useful for teaching because it makes planning and self-monitoring explicit learning goals.
3. In Uzbek EFL practice, grammatical competence tends to receive more attention than discourse, sociolinguistic and strategic competence. A component-based approach to lesson design and assessment, linked to CEFR 2020 descriptors, can help to close this gap.

For practitioners, the main recommendation is to name the target component at every lesson stage and to assess it with a matching tool. For researchers, the proposed framework offers criteria for evaluating whether digital and AI-based tools develop the full range of communicative competence or only its grammatical part.

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HERMANN VAMBERYNING “MARKAZIY OSIYOGA SAYOHAT” ASARIDA MARKAZIY OSIYO OBRAZI

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Annotatsiya.
Maqolada venger sharqshunosi Hermann Vambery (Herman Vamberi, 1832–1913) qalamiga mansub “Markaziy Osiyoga sayohat” (1864) asarida Markaziy Osiyo obrazining shakllanish mexanizmi tadqiq etiladi. Asarning kompozitsion tuzilishi miqdoriy jihatdan tahlil qilinib, turli makonlarga ajratilgan matn hajmi aniqlangan. Sinchkov o‘qish (close reading) va imagologik tahlil asosida mintaqa obrazi to‘rt komponentda – makon, xalq, hokimiyat va xavf – umumlashtirilgan. Natijalar Vamberi obrazining yagona “sharqshunoslik stereotipi”ga sig‘maydigan, ikki qutbli (ambivalent) tuzilishga ega ekanini ko‘rsatadi.

Kalit so‘zlar: Hermann Vambery, sayohatnoma, Markaziy Osiyo, imagologiya, obraz, orientalizm, Xiva, Buxoro, Samarqand, dervish niqobi.

KIRISH

XIX asrning ikkinchi yarmida Markaziy Osiyo Yevropa jamoatchiligi uchun ham siyosiy, ham ilmiy jihatdan muhim, biroq deyarli noma’lum mintaqa edi. Rossiya imperiyasining janubga siljishi va Britaniyaning Hindistondagi manfaatlari o‘rtasidagi raqobat – “Katta o‘yin” – mintaqa haqidagi har qanday ishonchli ma’lumotni qimmatli qilib qo‘ydi (Hoyte-West, 2026). Aynan shunday sharoitda venger sharqshunosi Hermann (Armin) Vamberyning 1863-yilda dervish qiyofasida Xiva, Buxoro va Samarqandga qilgan safari hamda uning natijasi bo‘lgan “Markaziy Osiyoga sayohat” (*Travels in Central Asia*, London, 1864) kitobi Yevropada katta shov-shuvga sabab bo‘ldi.

Asarning ilmiy qimmati bir necha jihatdan belgilanadi. Birinchidan, u Rossiya bosqinidan oldingi so‘nggi o‘n yillikdagi uch xonlik hayotini ichkaridan kuzatgan guvohning bayoni sifatida noyob manbadir (Malikov, 2022; Qosimov, 2023). Ikkinchidan, muallifning o‘zi ta’kidlaganidek, safarning asosiy maqsadi filologik edi: u venger tilining turkiy tillar bilan qarindoshligini “jonli tillar”ni amalda o‘rganish orqali aniqlamoqchi bo‘lgan (Vambery, 1864, pp. vii–viii). Uchinchidan, kitob G‘arb o‘quvchisi ongida Markaziy Osiyoning uzoq yillar saqlanib qolgan obrazini shakllantirdi.

So‘nggi o‘n yillikda Vamberi merosiga qiziqish sezilarli darajada ortdi. D. Mandlerning ilmiy biografiyasi (Mandler, 2016) va A. Loydning keng qamrovli tadqiqoti (Loyd, 2024) olimning ko‘p qirrali shaxsini – sayyoh, tilshunos, siyosiy maslahatchi va jamoat arbobi sifatidagi qiyofasini yoritdi. Shu bilan birga, asar talqinida ikki yo‘nalish o‘rtasida bahs davom etmoqda: bir guruh tadqiqotchilar kitobni E. Said nazariyasi doirasida “anti-sharqiy” narrativ sifatida baholasa (Gholi, 2016; Paidar & Pourqarib, 2018), boshqalari Vamberining ko‘p o‘rinlarda sharqshunoslik stereotiplaridan chetga chiqqanini ko‘rsatadi (Gholi & Ahmadi Mosaabad, 2024; Malikov, 2022).

Sayohatnoma janri XIX asrda keskin o‘zgarishlarni boshdan kechirdi. Temir yo‘l va paroxod davrida sayohat nisbatan yengillashgach, sayohatnomalar quruq tavsifdan muallifning his-tuyg‘ulari, fikr-mulohazalari va ichki kechinmalarini aks ettiruvchi shaxsiy, subyektiv shakllarga o‘ta boshladi (Davey, 2023). Yevropaliklarning dunyo bilan uchrashuvlari aynan shu janr orqali jamoatchilik mulkiga aylandi va milliy o‘zlikni anglash jarayonlari bilan ham bog‘landi (Gruber, 2022; Figes, 2019). Vamberining kitobi ana shu an’ananing chekka, ammo o‘ta ta’sirchan namunasidir: unda muallif bir vaqtning o‘zida sarguzasht qahramoni, etnograf, tilshunos va siyosiy kuzatuvchi sifatida namoyon bo‘ladi.

O‘zbek adabiyotshunosligida Vamberi nomi, asosan, “Buxoro yoxud Movarounnahr tarixi” asari va manbashunoslik nuqtayi nazaridan tilga olinadi (Ganieva, 2025; Qosimov, 2023). “Markaziy Osiyoga sayohat” asaridagi mintaqa obrazining badiiy-kompozitsion qurilishi esa alohida tadqiqot obyekti sifatida yetarlicha

o‘rganilmagan. Mazkur maqolaning **maqsadi** – asarda Markaziy Osiyo obrazi qanday komponentlardan tarkib topgani va qaysi mexanizmlar orqali shakllanganini aniqlashdir. Buning uchun quyidagi **vazifalar** qo‘yildi: 1) asar matnining makonlar bo‘yicha taqsimotini miqdoriy aniqlash; 2) obrazning asosiy komponentlarini ajratish va tipologiyasini tuzish; 3) obrazni shakllantirgan omillar modelini ishlab chiqish; 4) natijalarni so‘nggi tadqiqotlar bilan qiyoslash.

MATERIALLAR VA METODLAR

Tadqiqotning asosiy materiali – “Travels in Central Asia” asarining 1864-yilgi London (John Murray) nashri. Qiyosiy material sifatida muallifning 1884 va 1904-yillarda nashr etilgan ikki avtobiografiyasi hamda so‘nggi o‘n yilda (2016–2026) e’lon qilingan ilmiy adabiyotlar jalb qilindi. Qo‘shimcha ravishda muallif yo‘nalishini xaritaga tushirish uchun asarda tilga olingan manzillarning zamonaviy geografik koordinatalaridan foydalanildi.

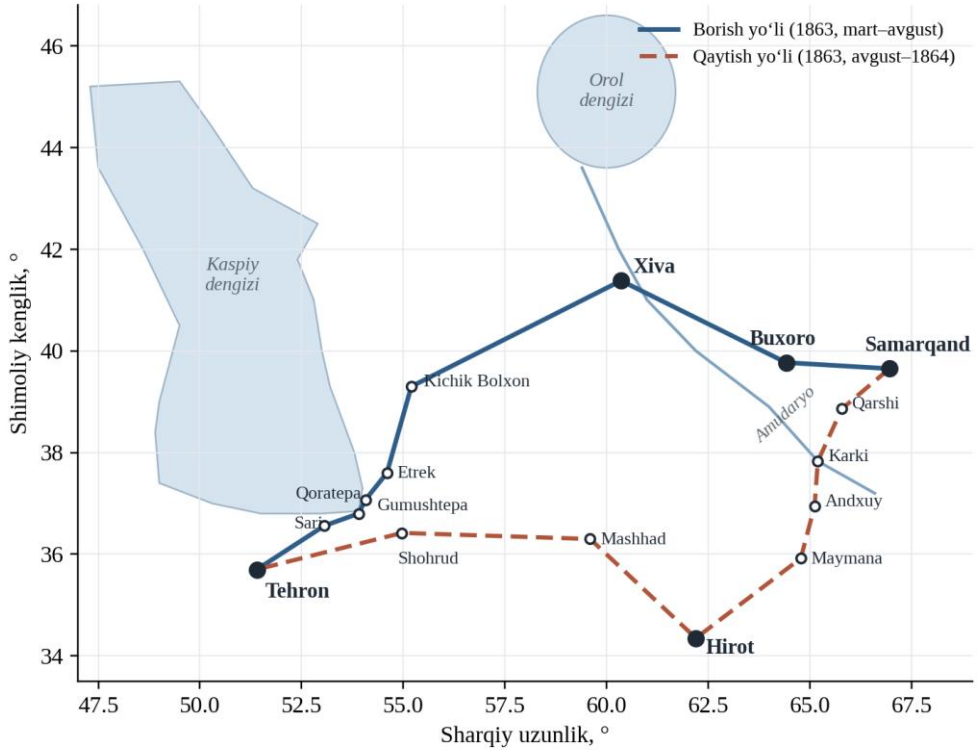
Tadqiqotda uch bosqichli metodika qo‘llandi. **Birinchi bosqichda** kompozitsion-miqdoriy tahlil o‘tkazildi: asar mundarijasidagi boblarning boshlanish sahifalariga tayanib, har bir bob va makonga ajratilgan sahifalar soni hisoblab chiqildi. Bu usul muallif e’tiborining qaysi hududlarda to‘planganini obyektiv o‘lchash imkonini beradi. **Ikkinchi bosqichda** sinchkov o‘qish (close reading) metodi qo‘llandi (Ohrvik, 2024): tanlangan parchalardagi epitet, qiyos, antiteza kabi vositalar va muallif baholari qayd etildi. **Uchinchi bosqichda** imagologik tahlil o‘tkazildi: “o‘z” va “o‘zga” munosabati, muallif pozitsiyasi va o‘quvchi kutuvi nuqtayi nazaridan obraz komponentlari tizimlashtirildi. Sayohatnomani subyektiv tajriba ifodasi sifatida o‘qish yondashuvi zamonaviy tadqiqotlarda ham asoslangan (Davey, 2023; Gruber, 2022).

Iqtiboslar asl ingliz tilidagi matndan muallif tomonidan o‘zbek tiliga tarjima qilingan; sahifalar 1864-yilgi nashr bo‘yicha ko‘rsatilgan.

NATIJALAR

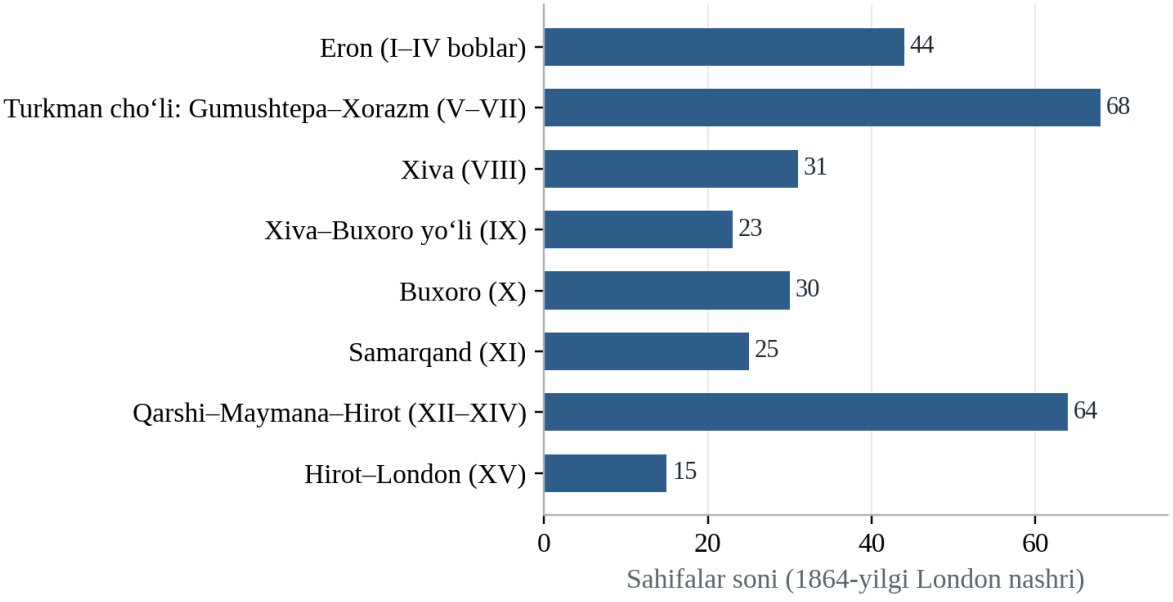
Safar yo‘nalishi va makon strukturasi. Asar ikki qismdan iborat: birinchisi Tehrondan Samarqandgacha va orqaga qaytish yo‘lining bayoni, ikkinchisi Markaziy Osiyoning geografiyasi, siyosiy tuzumi va ijtimoiy hayoti haqidagi ocherklar (Vambery, 1864, p. x). Muallifning yo‘nalishi 1-rasmda sxematik tarzda keltirilgan. Borish yo‘li Kaspiy bo‘yi – Turkman cho‘li – Xiva – Buxoro – Samarqand chizig‘ida, qaytish yo‘li esa Qarshi – Karki – Maymana – Hirot – Mashhad orqali o‘tgan.

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1-rasm. H. Vamberyning 1863–1864-yillardagi safar yo‘nalishi (sxema)
Manba: muallif tomonidan asar matni asosida tuzilgan; koordinatalar taxminiy.

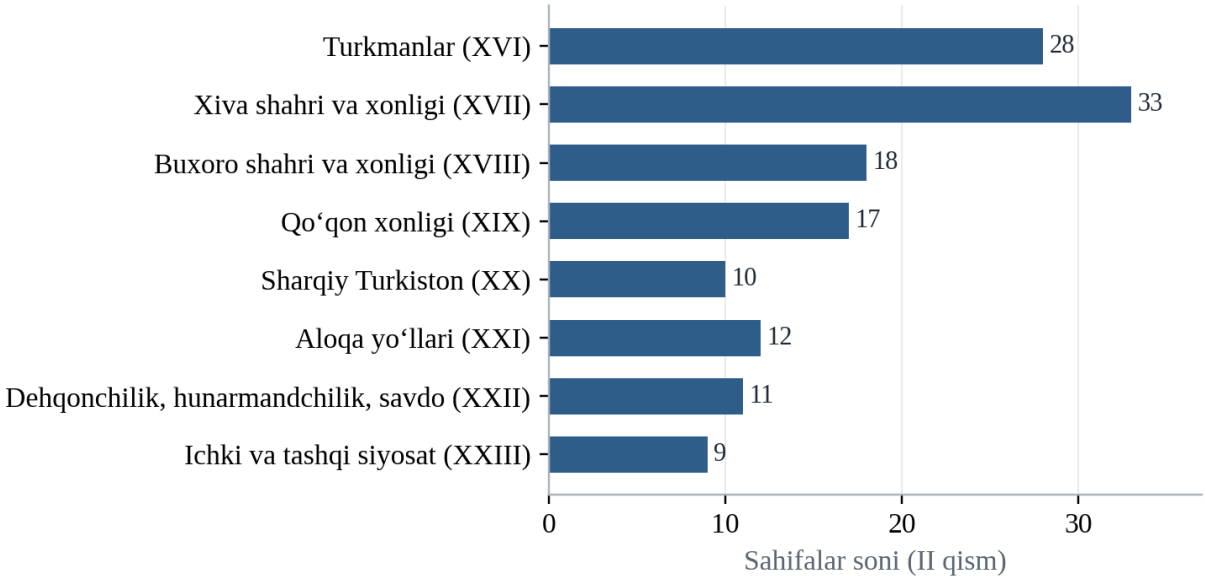
Kompozitsion-miqdoriy tahlil natijalari 2-rasmda keltirilgan. Birinchi qismning 300 sahifasidan eng katta hajm Turkman cho‘li (68 sahifa) va qaytish yo‘lidagi Afg‘oniston hududiga (64 sahifa) to‘g‘ri keladi. Uch xonlik markazlari – Xiva (31), Buxoro (30) va Samarqand (25 sahifa) – deyarli teng hajmda tasvirlangan. Demak, asarda shahar emas, balki **yo‘l va cho‘l** asosiy makon hisoblanadi: matnning qariyb yarmi shaharlar oralig‘idagi xavfli bo‘shliqni tasvirlashga bag‘ishlangan.



2-rasm. Asar I qismida turli makonlarga ajratilgan sahifalar soni

Manba: muallif hisob-kitobi (asar mundarijasi asosida).

Ikkinchi, ocherk xarakteridagi qismda manzara boshqacha (3-rasm). Bu yerda Xiva xonligiga eng ko‘p (33 sahifa), turkmanlarga 28, Buxoroga 18, Qo‘qon xonligiga 17 sahifa ajratilgan. Birinchi qismda “yo‘l obrazi” ustun bo‘lsa, ikkinchi qismda “davlat va xalq obrazi” – ya’ni tizimli, ma’lumotnoma tarzidagi tasvir birinchi o‘ringa chiqadi. Shu tariqa asarda ikki xil diskurs – badiiy-sarguzasht va ilmiy-statistik diskurs – yonma-yon mavjud.



3-rasm. Asar II qismining mavzular bo‘yicha taqsimoti (sahifalar)

Manba: muallif hisob-kitobi (asar mundarijasi asosida).

Obraz komponentlari. Sinchkov o‘qish natijasida Markaziy Osiyo obrazi to‘rt asosiy komponentdan tarkib topgani aniqlandi: makon (cho‘l, vohalar, shaharlar), xalq (turkmanlar, o‘zbeklar, tojiklar, hojilar), hokimiyat (xon, amir, ulamo) va xavf (qullik, josuslik, qatl). Bu komponentlarning turli makonlardagi namoyon bo‘lishi 1-jadvalda tizimlashtirildi.

1-jadval

“Markaziy Osiyoga sayohat” asarida makonlar obrazining tipologiyasi

Makon	Asosiy tasvir unsurlari	Baho ohangi	Narrativ vazifasi
Eron (Tehron, Mozandaron)	“Sa’diy va Hofizdagi Eron” bilan real qurg‘oqchilik ziddiyati; Mozandaron o‘rmonlari	Ambivalent	Kutuv va voqelik ziddiyati; Sharqqa “kirish ostonasi”
Turkman cho‘li (Gumushtepa, Etrek)	O‘tov, mehmondo‘stlik, “alamon” (bosqin), asirlar, suvsizlik, qum bo‘roni	Ikki qutbli	Sarguzasht va o‘lim xavfi; “tabiat bilan kurash”
Xiva	Xon qabuli, “boshlar evaziga to‘n”, asirlarning qatl etilishi	Salbiy	Despotiya va zo‘ravonlik obrazi
Buxoro	“Buxoroi sharif”, “islom uyasi”, josuslar, madrasalar, kitob bozori	Ambivalent	Muqaddaslik va nazorat makoni
Samarqand	Shohi Zinda, Temur maqbarasi, Ko‘ktosh, rasadxona; zamonaviy shaharning ahvoli	Hayrat va afsus	O‘tmish ulug‘vorligi va hozirgi tanazzul
Maymana, Hirot	Xarobalik, og‘ir soliqlar, amaldorlar zo‘ravonligi	Salbiy	Siyosiy tahlil, boshqaruv tanqidi

Manba: muallif tahlili; tavsiflar asar bob sarlavhalari va matni asosida (Vambery, 1864).

Makon. Obrazning birinchi qatlami – kutuv va voqelikning to‘qnashuvi. Asar boshidayoq muallif Eronni faqat Sa’diy, Xoqoniy va Hofiz asarlari yoki Gyotening “G‘arbu Sharq devoni” orqali bilgan o‘quvchining “achchiq hafsalasi pir bo‘lishi” haqida yozadi (Vambery, 1864, pp. 1–2). Shu tariqa matn romantik Sharq obrazini ongli ravishda yemirishdan boshlanadi. Tehrondan chiqayotganda muallif shaharga so‘nggi bor qarab, buni “Yevropa sivilizatsiyasining so‘nggi postiga xayrlashuv” deb ataydi va oldinda uni “vahshiylik va yovvoyilikning chekka ko‘rinishlari” kutayotganini qayd etadi (p. 21). Bu antiteza butun asarning makon modelini belgilaydi: G‘arb – tartib va xavfsizlik, Markaziy Osiyo – noma’lum va xavfli bo‘shliq.

Biroq makon tasviri faqat salbiy emas. Mozandaron tabiati “sehrli” o‘zgarish bilan quruq tog‘ manzarasidan boy va yam-yashil o‘lkaga aylanadi (p. 26), Samarqand esa Temur davri obidalari orqali hayrat ob’ekti bo‘ladi. A. Malikovning qayd etishicha, Vamberi 1863-yil avgustida Samarqandda sakkiz kun bo‘lgan va shahar tasvirida mahalliy musulmon madaniyatini kamsitish belgilari uchramaydi; muallifning afsusi ko‘proq shaharning o‘sha paytdagi ahvoliga qaratilgan (Malikov, 2022).

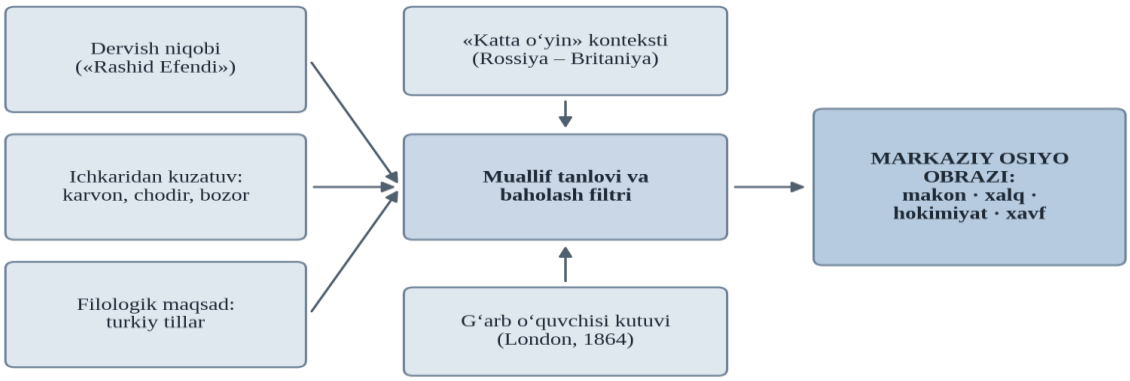
Xalq. Obrazning ikkinchi qatlami – odamlar. Bu yerda muallifning bahosi keskin tabaqalashgan. Hamrohlari bo‘lgan qashqarlik, qo‘qonlik va oqsulik hojilarni u “o‘sha yurtlarda uchratgan eng halol odamlar” deb ta’riflaydi (p. 22); ularning yirtiq kiyimlari ortida “qandaydir oliyjanoblik” borligini ta’kidlaydi (p. 11). Turkmanlarning mehmondo‘stligi muallifni lol qoldiradi: u bu fazilat haqida eshitgan, ammo uning bu darajaga yetishini “tush ko‘rmagan” (p. 46). Ayni paytda xuddi shu turkmanlar “alamon” – bosqin va qul savdosi bilan shug‘ullanuvchi xalq sifatida ham gavdalanadi. A. Gholi va M. Ahmadi Mosaabad ham muallifning qullarga nisbatan chuqur hamdardligini qayd etadi (Gholi, 2016; Gholi & Ahmadi Mosaabad, 2024).

Hokimiyat. Uchinchi komponent – siyosiy va diniy hokimiyat. Muallif kuzatuviga ko‘ra, ko‘chmanchilar orasida real ta’sir kuchi oqsoqollarda emas, balki ulamolarda: Yevropada ustun deb hisoblangan oqsoqollar nufuzi amalda kichik (p. 52). Xiva bobida esa hokimiyat obrazi zo‘ravonlik bilan uyg‘unlashadi: bob sarlavhalarida “Boshlar evaziga beriladigan sarpo” va “Asirlarning dahshatli qatl etilishi” kabi iboralar keladi. Bu tasvirlar G‘arb o‘quvchisi uchun “Sharq despotiyasi” obrazini mustahkamladi.

Xavf. To‘rtinchi komponent – doimiy xavf hissi. Muallif so‘zboshida o‘zini “eshitish surbetlik, so‘rash jinoyat, yozib olish esa o‘limga loyiq gunoh” hisoblangan mamlakatdan qaytgan odam sifatida taqdim etadi (p. ix). Buxoro esa Markaziy Osiyoda u “chindan qo‘rqqan yagona shahar” sifatida tilga olinadi (p. 12). Xavf motivi niqob motivi bilan chambarchas bog‘liq: Tehrondan chiqishdanoq muallif o‘zini Usmonli dervishi Rashid Efendi deb tanishtiradi va Sharq kishisi “ilmga chanqoqlikni tushunmaydi” degan xulosaga tayanib, asl maqsadini yashiradi (p. 13).

Til va niqob. Obrazning o‘ziga xosligini belgilagan yana bir omil – muallifning til bilan munosabati. Vamberi Istanbulda bir necha yil turk xonadonlarida yashab, o‘zini “turkka, hatto efendiga aylangan” deb ta’riflaydi (Vambery, 1864, p. viii). Aynan til bilimi unga karvonda “Hoji Rashid” sifatida qabul qilinish, hamrohlarining Qo‘qon, Marg‘ilon va Namangan bog‘lari haqidagi hikoyalarini tinglash, ularning qo‘shiqlaridagi venger kuylariga o‘xshashlikni sezish imkonini bergan (pp. 24–25). Shu tariqa matnda Markaziy Osiyo xalqlari ko‘pincha tashqaridan emas, balki ular bilan bir dasturxonda non sindirgan, birga “Alloh, yo Alloh!” deya zikr tushgan hamroh nigohi orqali ko‘rsatiladi. Bu – “o‘zga”ni tasvirlashning Yevropa sayohatnomalarida kam uchraydigan, ichkaridan qarash strategiyasidir.

Obraz shakllanishi modeli. Tahlil natijalari obrazni shakllantirgan omillarni 4-rasmdagi model ko‘rinishida umumlashtirish imkonini berdi. Unga ko‘ra, “ichkaridan kuzatuv” (dervish niqobi, karvon va chodir hayoti) va filologik maqsad muallifga noyob empirik material bergan, biroq bu material “Katta o‘yin” siyosiy konteksti va London o‘quvchisining kutuvi orqali saralangan.



4-rasm. Asarda Markaziy Osiyo obrazining shakllanish modeli

Manba: muallif ishlanmasi.

MUHOKAMA

Olingan natijalarni so‘nggi tadqiqotlar bilan qiyoslash asar talqinidagi bahsni aniqroq ko‘rish imkonini beradi (2-jadval). Postkolonial yondashuv tarafdorlari Vamberi Markaziy Osiyoni “vaqtda muzlab qolgan”, zolim hukmdorlar boshqaradigan hudud sifatida tasvirlab, o‘z shaxsini yuksaltirgan deb hisoblaydi (Gholi, 2016); ayrim mualliflar esa asarni ochiqdan-ochiq G‘arbni ustun qo‘yuvchi, buzilgan bilimga asoslangan narrativ deb baholaydi (Paidar & Pourqarib, 2018).

2-jadval

So‘nggi o‘n yillikda (2016–2026) Vamberi merosi bo‘yicha asosiy tadqiqotlar

Muallif, yil	Yondashuv	Asosiy xulosa
Mandler (2016)	Biografik-tahliliy	Vamberining Vengriya va Britaniyadagi ko‘p qatlamli identitetlari; rusofob siyosiy pozitsiyasi
Gholi (2016)	Postkolonial	Mintaqa salbiy, “muzlagan” makon sifatida berilgan; muallif “men”i yuksaltirilgan
Paidar & Pourqarib (2018)	Postkolonial (E. Said)	Asar Sharqqa qarshi, G‘arbni ustun qo‘yuvchi narrativ
Malikov (2022)	Tarixiy-madaniy	Samarqand tasvirida mahalliy madaniyatni kamsitish yo‘q; muallif keyingi sharqshunoslarga ta’sir qilgan
Gholi & Ahmadi Mosaabad (2024)	Revizionist	Asarda orientalizm normalaridan chetga chiqishning uchta holati aniqlangan
Loyd (2024)	Biografik	Muallif o‘z hayot hikoyasini qayta-qayta, bezab yozgan; “o‘zgaruvchan persona”
Ganieva (2025)	Manbashunoslik	Kundaliklar va maktublar ilk bor ilmiy muomalaga kiritilgan
Hoyte-West (2026)	Memuar tahlili	Yevropa imperiyalaridagi qabul turlicha bo‘lgan; olim “begona” maqomini yengib o‘tgan

Manba: muallif tomonidan tuzilgan.

Bizning natijalarimiz har ikki qarashning qisman to‘g‘riligini ko‘rsatadi, biroq ularning birortasi ham asar obrazining to‘liq manzarasini bermaydi. Birinchidan, kompozitsion tahlil asarning markazida “Sharq” emas, “yo‘l” turganini ko‘rsatdi: cho‘l va shaharlararo bo‘shliq tasviri shaharlar tasviridan qariyb ikki baravar ko‘p. Shu bois salbiy baholar ko‘pincha umuman mintaqaga emas, balki xavf va qiyinchilik bilan bog‘liq yo‘l tajribasiga taalluqli. Ikkinchidan, xalq obrazidagi ijobiy qutb (hojilar halolligi, turkman mehmondo‘stligi) va hokimiyat obrazidagi salbiy qutb (Xiva qatllari, Buxoro nazorati) aniq ajralib turadi. Demak, Vamberining tanqidi, asosan, hokimiyat institutlariga qaratilgan, xalq esa ko‘p hollarda hamdardlik bilan tasvirlangan.

Uchinchidan, muallifning shaxsiy pozitsiyasi ham e'tiborga olinishi lozim. D. Mandler ta'kidlaganidek, Vamberining o'zi Yevropada ham "chetdan kelgan" odam edi – kambag'al yahudiy oilasida tug'ilgan, universitet ta'limi olmagan olim sifatida u Sharq va G'arb o'rtasida vositachi mavqeini egallagan (Mandler, 2016). Keyingi avtobiografiyalarida u Usmonli zodagonlarining kamtarligini Yevropa aristokratiyasining takabburligiga qarshi qo'yadi (Hoyte-West, 2026). Bu dalil Vamberining "Sharq – past, G'arb – yuqori" degan sodda sxemadan ancha murakkab pozitsiyada turganini ko'rsatadi. Shu bilan birga, A. Loyd qayd etganidek, muallif o'z sarguzashtlarini yillar davomida qayta-qayta bezab hikoya qilgan (Loyd, 2024); demak, asardagi obraz faqat kuzatuv emas, balki ongli ravishda qurilgan adabiy konstruksiya hamdir.

To'rtinchidan, obrazni shakllantirgan siyosiy omil ham inkor etilmaydi. K. Hamilton va M. Sarközy tadqiqotlari Vamberining keyinchalik Britaniya diplomatiyasi va konservativ siyosatchilari bilan yaqin aloqada bo'lganini ko'rsatadi (Hamilton, 2016; Sarközy, 2020). Asarning so'nggi bobi aynan "Markaziy Osiyoda ruslar va inglizlar raqobati"ga bag'ishlangani (Vambery, 1864, XXIV bob) kitobning siyosiy auditoriyaga ham mo'ljallanganini tasdiqlaydi. Biroq mintaqa obrazining asosiy qatlamlari – makon, xalq, maishat – bevosita kuzatuvga tayanadi va ular bugungi kunda ham tarixiy-etnografik manba sifatida qimmatini yo'qotmagan (Qosimov, 2023; Toprak, 2023).

Beshinchidan, Vamberi obrazining lingvistik asoslari so'nggi yillarda alohida e'tibor qozonmoqda. A. Hoyte-Westning tadqiqoti muallifning Istanbuldagi yillarida til bilimini ijtimoiy yuksalish vositasiga aylantirganini ko'rsatadi (Hoyte-West, 2024). F. Toprak esa Vamberi 1867-yilda "Chig'atoy tili tadqiqotlari"da to'plagan 112 ta o'zbekcha naqlni (maqolni) tahlil qilib, ularning qay biri hozirgi o'zbek tilida saqlanib qolganini aniqlagan (Toprak, 2023). Bu faktlar "Markaziy Osiyoga sayohat"dagi xalq obrazining ortida jiddiy filologik kuzatuv turganini tasdiqlaydi: muallif uchun mintaqa, avvalo, jonli til va og'zaki madaniyat makoni bo'lgan. Sh. Ganievaning qayd etishicha, aynan shu safar natijasida Vengriyada Markaziy Osiyo madaniyatini o'rganish maktabi vujudga kelgan (Ganieva, 2025).

Nihoyat, asardagi obrazning keyingi davr sharqshunosligiga ta'siri masalasi ham muhim. A. Malikov Vamberining Samarqand haqidagi fikrlari keyingi yevropalik sharqshunoslarning shahar haqidagi tasavvuriga katta ta'sir ko'rsatganini ta'kidlaydi (Malikov, 2022). Bu shuni anglatadiki, 1864-yilgi kitobda yaratilgan obraz o'z davri bilan cheklanib qolmay, XIX asr oxiri – XX asr boshidagi Yevropa sayohatnomalari uchun o'ziga xos "boshlang'ich matn" vazifasini o'tagan. Shu sababli bu obrazni tanqidiy, ammo tarixiy kontekstni hisobga olgan holda o'rganish bugungi o'zbek adabiyotshunosligi uchun ham dolzarb ahamiyatga ega.

XULOSA

Hermann Vamberyning "Markaziy Osiyoga sayohat" asarida mintaqa obrazi to'rt komponentdan – makon, xalq, hokimiyat va xavfdan tarkib topgan bo'lib, ular turli makonlarda turlicha nisbatda namoyon bo'ladi. Asar bo'yicha o'tkazilgan kompozitsion-miqdoriy tahlil shuni ko'rsatdiki, uning birinchi qismida asosiy makon shahar emas, balki yo'l va cho'l hisoblanadi: jumladan, Turkman cho'li va Afg'oniston hududi tasviri (132 sahifa) uch xonlik markazlari tasviridan (86 sahifa) sezilarli darajada ko'p bo'lib, ikkinchi qismda esa tizimli, ma'lumotnoma xarakteridagi "davlat va xalq" diskursi ustunlik qiladi. Asardagi mintaqa obrazi ikki qutbli tuzilishga ega bo'lib, xalq, ayniqsa, hojilar va ko'chmanchilar ko'p hollarda hamdardlik bilan tasvirlangan, keskin tanqidiy yondashuv esa hokimiyat institutlariga (Xiva jazolari, Buxoro nazorati, Afg'on amaldorlari zo'ravonligi) qaratilgan.

Mazkur obrazning shakllanishiga dervish niqobi orqali ichkaridan kuzatuv, ilmiy-filologik maqsad, "Katta o'yin" siyosiy konteksti va G'arb o'quvchisining kutuvi birgalikda ta'sir ko'rsatgan, shu sababli asarni yagona "orientalistik stereotip" doirasida baholash uning mazmunini soddalashtiradi. Ushbu tadqiqot natijalaridan o'zbek adabiyotshunosligida xorijiy sayohatnomalardagi O'zbekiston obrazini o'rganishda, shuningdek, qiyosiy adabiyotshunoslik va imagologiya kurslarida foydalanish mumkin; kelgusidagi tadqiqotlarda asarning venger (Közep-azsiai utazas, 1865) va ingliz nashrlarini qiyoslash hamda muallifning boshqa asarlaridagi Markaziy Osiyo obrazini o'rganish istiqbolli yo'nalish hisoblanadi.

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“NAVOIY” VA “ALISHER NAVOIY” ROMANLARIDA TARIXIY MAKON VA DAVR MUAMMOLARI

Abdusattorova Maftuna Bahodirovna
Sharof Rashidov nomidagi aniq va tabiiy fanlarga ixtisoslashtirilgan maktab o‘qituvchisi

Annotatsiya.
Maqolada Oybekning “Navoiy” (1944) va Isajon Sultonning “Alisher Navoiy” (2021) romanlarida tarixiy makon va davr (xronotop) talqini qiyosiy aspektda tadqiq etiladi. M.M.Baxtinning xronotop nazariyasi asosida har ikki asarda tarixiy zamonning qamrovi, zamonni tashkil etish tamoyili, makon tipologiyasi hamda tarixiy haqiqat va badiiy to‘qima nisbati aniqlanadi. Tahlil natijasida Oybek romanida zamon 1469–1501-yillardagi ijtimoiy-siyosiy voqealar bilan chegaralangani, makon esa Hirot saroyi va shahar muhiti atrofida jamlangani; Isajon Sulton romanida esa zamon qahramonning butun umrini qamrab olib, “Xazoyin ul-maoniy” devonlarining to‘rt bosqichli tuzilishiga muvofiq tashkil etilgani, makon esa ichki-ruhiy va ramziy qatlamlar bilan boyitilgani asoslab beriladi.

Kalit so‘zlar: tarixiy roman, xronotop, tarixiy makon, badiiy zamon, Oybek, Isajon Sulton, Alisher Navoiy obrazi, tarixiy haqiqat, badiiy to‘qima.

KIRISH

Tarixiy roman o‘tmish voqeligini badiiy idrok etish va uni zamondosh o‘quvchi ongiga yetkazishning eng murakkab shakllaridan biridir. Bu janrda yozuvchi ikki yoqlama mas’uliyatni zimmasiga oladi: bir tomondan, tarixiy faktga sodiq qolishi, ikkinchi tomondan, o‘tmishni jonli va ruhiy jihatdan ishonarli badiiy olam sifatida qayta yaratishi lozim. G.Lukach ta’kidlaganidek, tarixiy romanda buyuk tarixiy voqealarni qayta hikoya qilish emas, balki shu voqealarda ishtirok etgan insonlarni poetik jihatdan “uyg‘otish” muhimdir [4]. Demak, tarixiy asarning badiiy qimmati ko‘p jihatdan muallif tarixiy makon va zamonni qanday qayta qurganiga bog‘liq.

O‘zbek adabiyotida Alisher Navoiy siymosi badiiy talqinning eng mas’uliyatli obyektlaridan biri bo‘lib kelgan. Oybek 1940-yilda yozishni boshlab, 1942-yilda tugatgan va 1944-yilda nashr ettirgan “Navoiy” romani ulug‘ shoir va mutafakkir obrazini yaratgan birinchi yirik epik asar sifatida e’tirof etiladi; asar 1946-yilda Davlat mukofotiga sazovor bo‘lgan va ko‘plab tillarga tarjima qilingan. Oradan qariyb sakson yil o‘tib, 2021-yilda Isajon Sultonning “Alisher Navoiy” romani nashr etildi [2]. Ikki asarni yaratilish davri, badiiy-estetik tamoyillari va Navoiy shaxsiga munosabati jihatidan bir-biridan farq qiluvchi ikki adabiy davrning namunasi sifatida ko‘rish mumkin.

Mazkur romanlar yuzasidan muayyan tadqiqotlar amalga oshirilgan. Jumladan, D.Umaraliyeva ikki asardagi Navoiy obrazini, xususan, qahramonning yoshlik davriga oid epizodlarni qiyoslagan [5], G.Nurullayeva Isajon Sulton romanining kompozitsiyasi va til xususiyatlarini tahlil qilgan [6], M.Qodirova ikki romanni qiyosiy o‘rganishning metodik imkoniyatlarini ko‘rsatgan [7], B.Karim esa Isajon Sulton romanining g‘oyaviy-badiiy mohiyatini yoritgan [8]. Biroq mavjud ishlarda tarixiy makon va zamon muammosi, ya’ni asarlarning xronotop tizimi maxsus tadqiqot obyekti sifatida yaxlit o‘rganilmagan. Vaholanki, aynan makon va zamonning badiiy modeli tarixiy romanda obraz talqinini, konflikt tabiatini va muallif konsepsiyasini belgilab beradi.

Tadqiqotning maqsadi – Oybekning “Navoiy” va Isajon Sultonning “Alisher Navoiy” romanlarida tarixiy makon va davrning badiiy talqinini qiyosiy o‘rganib, har ikki asarga xos xronotop modellarini aniqlashdan iborat. Maqsaddan kelib chiqib, quyidagi **vazifalar** belgilandi:

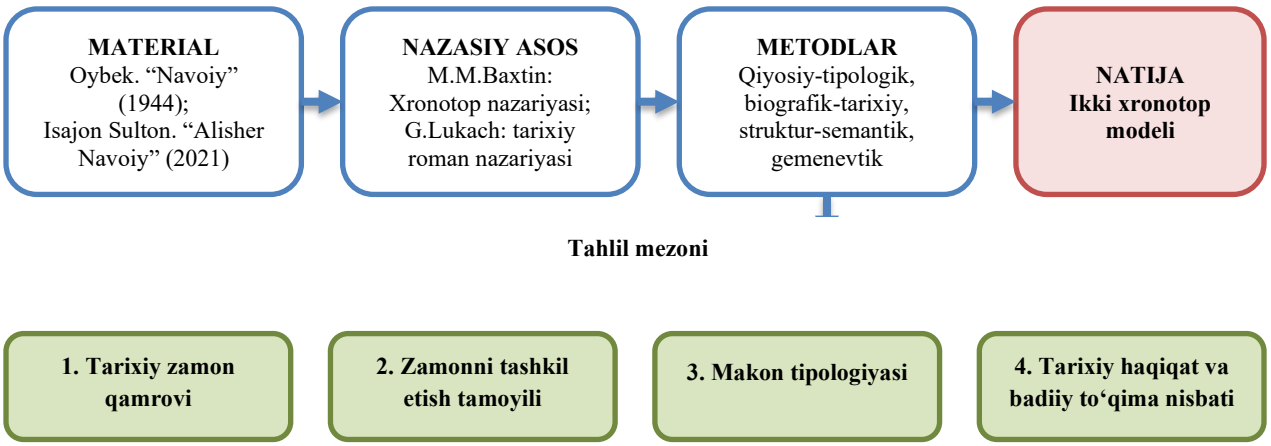
1) romanlarda tasvirlangan tarixiy zamon qamrovini aniqlash;
2) badiiy zamonni tashkil etish tamoyillarini ochib berish;
3) makon tipologiyasini tuzish va qiyoslash;
4) tarixiy haqiqat va badiiy to‘qima nisbatini baholash.

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MATERIAL VA METODLAR

Tadqiqot materiali sifatida Oybekning “Navoiy” romani (Toshkent: Sharq, 2004) [1] va Isajon Sultonning “Alisher Navoiy” romani (Toshkent: Adabiyot, 2021) [2] matnlari olindi. Nazariy asos vazifasini M.M.Baxtinning xronotop haqidagi ta’limoti o‘tadi. Olim xronotopni adabiyotda badiiy o‘zlashtirilgan makon va zamon munosabatlarining uzviy bog‘liqligi, ya’ni adabiyotning shakliy-mazmuniy kategoriyasi sifatida ta’riflaydi [3]. Shuningdek, adabiyot nazariyasi va mumtoz poetikaga oid o‘zbek olimlarining ishlariga tayanildi [9; 10; 11].

Tadqiqotda quyidagi metodlar qo‘llanildi: *qiyosiy-tipologik* metod – ikki asarning mushtarak va farqli jihatlarini aniqlash uchun; *biografik-tarixiy* metod – roman voqealarini Navoiy hayotining tarixiy manbalarda qayd etilgan sanalari bilan solishtirish uchun; *struktur-semantik* tahlil – kompozitsiya, qism va boblar tizimi, sarlavhalar semantikasini o‘rganish uchun; *germenevtik* talqin – ramziy obraz va detallarning ma’nosini ochish uchun. Tahlil to‘rt mezon asosida olib borildi (1-rasm).



1-rasm. Tadqiqot dizayni va tahlil mezonlari

Makon qatlamlarining ifodalanish darajasi uch bosqichli sifat shkalasi (“sust”, “o‘rta”, “yetakchi”) orqali baholandi. Baholashda tegishli makon turining syujet rivojidagi funksiyasi, tasvirga ajratilgan o‘rni va obraz ruhiyatini ochishdagi ahamiyati inobatga olindi. Ushbu baholash muallif talqiniga asoslanganini alohida qayd etamiz.

NATIJALAR

3.1. Tarixiy zamon qamrovi

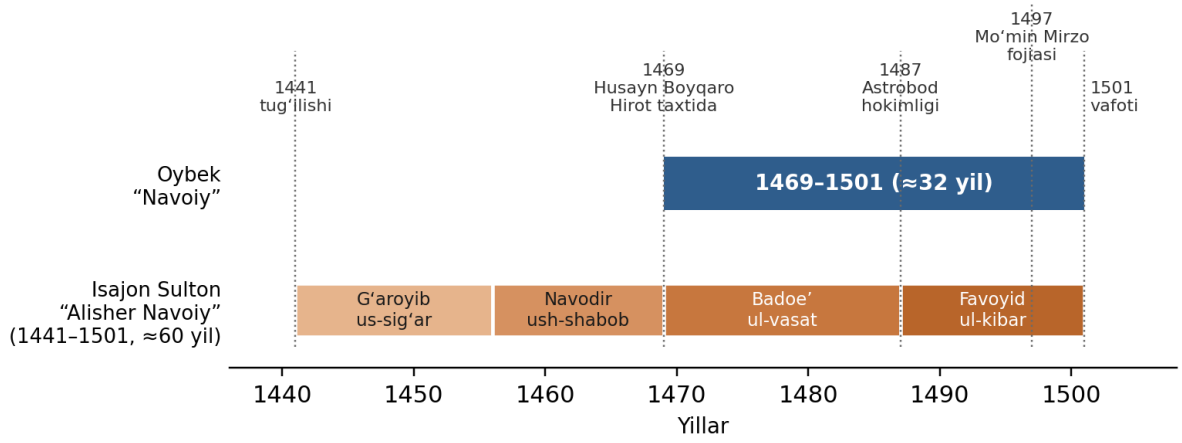
Oybek romani voqealari Husayn Boyqaroning Hirot taxtini egallashi (1469) va shu munosabat bilan Alisherning Samarqanddan Hirotga qaytishi bilan boshlanib, shoirning vafoti (1501) bilan yakunlanadi. Demak, asarda qariyb o‘ttiz ikki yillik davr – qahramon hayotining yigirma sakkiz yoshdan umrining oxirigacha bo‘lgan etuklik va keksalik bosqichlari qamrab olingan. Navoiyning bolalik va yoshlik yillari syujetda bevosita tasvirlanmaydi.

1-jadval

Romanlarning qiyosiy tavsifi

Ko‘rsatkich	Oybek. “Navoiy”	Isajon Sulton. “Alisher Navoiy”
Nashr etilgan yili	1944 (yozilgan: 1940–1942)	2021 (Toshkent: Adabiyot)
Adabiy davr	Sovet davri, 1940-yillar	Mustaqillik davri
Tarixiy zamon qamrovi	1469–1501 (≈32 yil)	1441–1501 (≈60 yil)
Qahramon hayotining bosqichlari	etuklik va keksalik	bolalik, yoshlik, o‘rta yosh, keksalik
Kompozitsion tuzilish	xronologik-chiziqli izchillik	“Xazoyin ul-maoniy” devonlariga muvofiq to‘rt qism
Asosiy makon	Hirot (saroy va shahar)	Hirot va qahramon hayot yo‘lidagi makonlar
Zamonni tashkil etuvchi omil	ijtimoiy-siyosiy voqealar	umr fasllari, ma’naviy kamolot bosqichlari

Isajon Sulton romanida esa zamon qahramonning butun umrini – 1441-yildagi tavalludidan 1501-yildagi vafotigacha bo‘lgan oltmish yillik davrni qamrab oladi (1-jadval, 2-rasm). Natijada tarixiy zamon qamrovi Oybek romaniga nisbatan qariyb ikki barobar kengaygan (32 yilga nisbatan 60 yil).



Izoh: Isajon Sulton romani qismlarining yillar bo‘yicha chegaralari shartli (umr bosqichlariga ko‘ra) ko‘rsatilgan.

2-rasm. Romanlarda tarixiy zamonning qamrovi (xronologik sxema)

3.2. Badiiy zamonni tashkil etish tamoyili

Oybek romanida zamon xronologik-chiziqli tamoyil asosida tashkil etilgan. Voqealar tarixiy ketma-ketlikda rivojlanadi, zamon ritmini esa saroy hayotidagi siyosiy o‘zgarishlar, fitnalar va ijtimoiy ziddiyatlar belgilaydi. Bu yerda zamon, eng avvalo, ijtimoiy-tarixiy zamondir: qahramonning ichki kechinmalari ham asosan davlat va jamiyat hayotidagi voqealarga munosabat tarzida ochiladi.

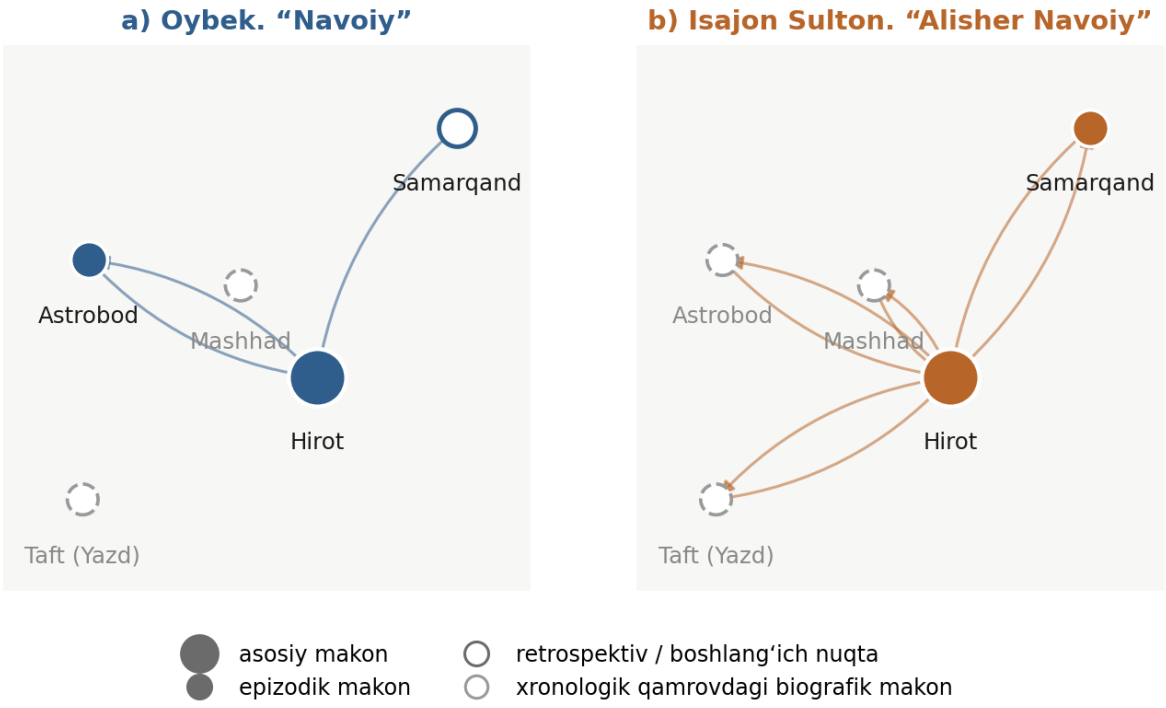
Isajon Sulton romanida zamon boshqa tamoyil – umr fasllari tamoyili asosida qurilgan. Asar to‘rt qismdan iborat bo‘lib, ular Navoiyning “Xazoyin ul-maoniy” kulliyotiga kirgan to‘rt devon – “G‘aroyib us-sig‘ar” (“Bolalik g‘aroyibotlari”), “Navodir ush-shabob” (“Yigitlik nodirotlari”), “Badoe’ ul-vasat” (“O‘rta yosh badialari”) va “Favoyid ul-kibar” (“Keksalik foydalari”) nomlari bilan ataladi. Shu tariqa roman zamoni shoirning o‘zi she’riy merosini tartiblashda qo‘llagan “umr zamoni” modeliga bo‘ysundiriladi: tarixiy xronologiya shaxsning ma’naviy kamolot bosqichlari bilan uyg‘unlashadi. Tadqiqotchilar ham asarning struktura va kompozitsiya jihatidan pishiq ekanini qayd etadi [6].

Isajon Sulton romanida zamon ramziy qatlam bilan ham boyitilgan. Masalan, Mo‘min Mirzo fojiasi tasvirida tun obrazi voqealarning dramatik cho‘qqisiga aylanadi: yozuvchi ta’biricha, “tun jodugari vaqt xuftondan o‘tgandan so‘ng, makr-hiyla to‘rini” keng yoyadi, saroy uzra esa go‘yo “musibat qushi” uchib yuradi [2]. Bu yerda tabiiy vaqt (tun, xufton) axloqiy-ramziy mazmun kasb etib, zamon va makon yagona obrazli tizimga birlashadi.

3.3. Makon tipologiyasi

Har ikki romanda Hirot markaziy makon hisoblanadi, ammo uning badiiy funksiyasi farqlanadi. Oybek Hirotni keng ijtimoiy panorama sifatida tasvirlaydi: saroy, madrasa, bozor, hunarmandlar hayoti va xalq turmushi bir butun “shahar organizmi”ni tashkil etadi. Saroy – hokimiyat, fitna va siyosiy kurash makoni; shahar esa Navoiyning xalqparvarlik faoliyati namoyon bo‘ladigan ijtimoiy maydon. Astrobod epizodi qahramonning saroydan uzoqlashtirilishi, ya’ni siyosiy ajralish makoni sifatida talqin etiladi; Samarqand esa asosan syujetning boshlang‘ich nuqtasi sifatida esga olinadi (3-rasm, a).

Isajon Sulton romanida makon qahramonning butun hayot yo‘li bo‘ylab kengayadi. Hirot bilan bir qatorda Samarqand ham mustaqil badiiy makon sifatida gavdalanadi; bu jihat Navoiyning Samarqanddagi faoliyati talqiniga bag‘ishlangan maxsus tadqiqotda ham qayd etilgan [12]. Romanning xronologik qamrovi shoir bolaligi va yoshligini ham o‘z ichiga olgani sababli uning badiiy geografiyasi biografik manbalarda qayd etilgan boshqa makonlar (Mashhad, Taft, Astrobod) bilan bog‘lanish imkoniga ega (3-rasm, b).



3-rasm. Romanlarda tarixiy makonning geografik sxemasi: a – Oybek, b – Isajon Sulton (nuqtalarning joylashuvi taxminiy koordinatalarga asoslangan)

Makonni qatlamlar bo‘yicha tahlil qilish ikki asar o‘rtasidagi tub farqni yanada aniq ko‘rsatadi (2-jadval, 4-rasm). Oybek romanida real-geografik va ijtimoiy-maishiy makon yetakchilik qiladi; ichki-ruhiy makon qahramonning mulohazalari va ichki monologlari orqali ochiladi, ramziy makon esa nisbatan sust ifodalangan.

	Oybek “Navoiy”	Isajon Sulton “Alisher Navoiy”
Real-geografik makon	**yetakchi**	**yetakchi**
Ijtimoiy-maishiy makon (saroy, bozor, madrasa)	**yetakchi**	o‘rta
Ichki-ruhiy makon (ko‘ngil, xotira, tush)	o‘rta	**yetakchi**
Ramziy makon (tun, yo‘l, ramziy detal)	sust	**yetakchi**

4-rasm. Makon qatlamlarining romanlarda ifodalanish darajasi (muallif baholashi)

Isajon Sulton romanida real makon bilan bir qatorda ichki-ruhiy (ko‘ngil, xotira, tush) va ramziy (tun, yo‘l, ramziy detallar) makon yetakchi o‘rinni egallaydi. Romanda peyzajning syujet rivoji va davr ruhini ochishdagi roliga bag‘ishlangan tadqiqotlar [13] ham ushbu xulosani tasdiqlaydi.

2-jadval

Makon tipologiyasi va uning badiiy funksiyasi

Makon turi	Oybek. “Navoiy”	Isajon Sulton. “Alisher Navoiy”
Real-geografik	Hirot, Astrobod; Samarqand – boshlang‘ich nuqta	Hirot, Samarqand va shoir hayot yo‘lidagi boshqa shaharlar
Ijtimoiy-maishiy	saroy – fitna va siyosiy kurash maydoni; bozor, madrasa, hunarmandlar – xalq hayoti panoramasi	saroy – ma’naviy sinov maydoni; ijtimoiy fon qahramon ruhiyatiga bo‘ysundirilgan
Ichki-ruhiy	ichki monolog va mulohazalar; asosan ijtimoiy muammolarga munosabat	ko‘ngil, xotira, tush – obrazning asosiy mavjudlik makoni
Ramziy	ayrim detallar darajasida	tun, yo‘l, ramziy detallar – axloqiy-falsafiy mazmun tashuvchi obrazlar

3.4. Tarixiy haqiqat va badiiy to‘qima nisbati

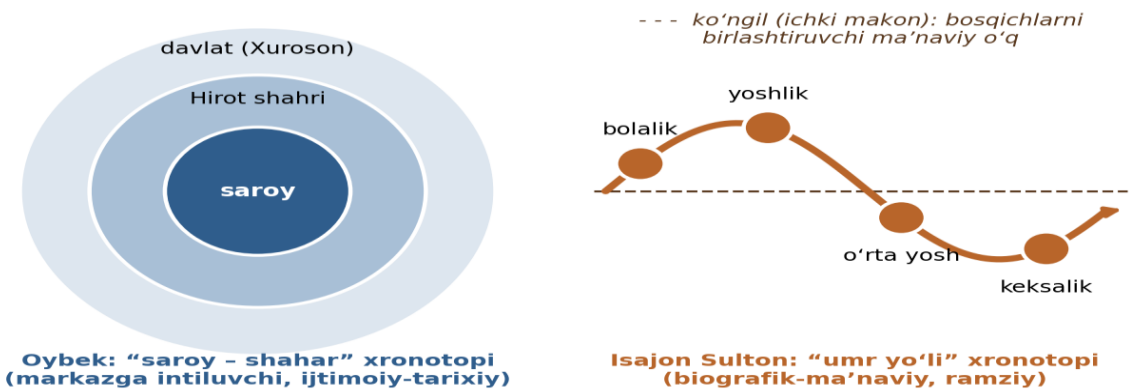
Oybek romanida tarixiy shaxslar (Navoiy, Husayn Boyqaro, Abdurahmon Jomiy, Kamoliddin Behzod, Mirxond, Xondamir, Majididdin, Nizomulmulk) bilan bir qatorda Arslonqul, Dildor, Sultonmurod kabi to‘qima obrazlar muhim o‘rin tutadi. Ular orqali yozuvchi xalq hayoti, oddiy kishilar taqdiri va ijtimoiy ziddiyatlarni asarga olib kiradi; natijada tarixiy makon jamiyatning quyi qatlamlari hisobiga kengayadi.

Isajon Sulton romanida tarixiy shaxslar doirasi qahramon hayotining ilk davri hisobiga kengaygan: masalan, Temuriylar sulolasining nufuzli vakilasi Gavharshodbegim obrazi ham asardan o‘rin olgan. Yozuvchi tarixiy faktlar orasidagi bo‘shliqlarni ruhiy-psixologik tahlil, ramziy epizodlar va mumtoz nasrga yaqin badiiy til vositasida to‘ldiradi. Bu hol zamonaviy o‘zbek romanchiligida badiiy psixologizmning kuchayishi bilan bog‘liq umumiy tendensiyaga mos keladi [14].

MUHOKAMA

Olingan natijalar ikki romandagi tarixiy makon va zamon talqini tasodifiy emas, balki har bir asar yaratilgan davrning estetik talablari va muallif konsepsiyasi bilan bog‘liq ekanini ko‘rsatadi. Oybek romani 1940-yillarda – sotsialistik realizm metodi hukmron bo‘lgan, tarixiy mavzuga sinfiy yondashuv talab etilgan va Ikkinchi jahon urushi sharoitida vatanparvarlik ruhi kuchaygan davrda yaratilgan. Shu bois yozuvchi Navoiyni, eng avvalo, xalqparvar davlat arbobi, adolat va ma’rifat homiysi sifatida ko‘rsatadi; romanda shoirning ijodiy jarayoniga nisbatan uning ijtimoiy-siyosiy faoliyati kengroq o‘rin egallaydi. Tarixiy makonning saroy va shahar atrofida jamlanishi, zamonning ijtimoiy-siyosiy voqealar bilan o‘lchanishi aynan shu konsepsiyadan kelib chiqadi.

Isajon Sulton romani mustaqillik davrida, milliy-ma’naviy merosni mafkuraviy qoliplardan xoli holda qayta anglash jarayonida yaratildi. Yozuvchi Navoiy shaxsini ijtimoiy funksiya bilan cheklamay, uni ko‘ngil egasi, shoir va mutafakkir, komil inson ideali sifatida talqin qiladi. B.Karim ushbu asarni “Insoniyat quyoshi ta’rifida bitilgan roman” sifatida baholaydi [8]. Zamonning umr fasllari bo‘yicha tuzilishi, makonning ichki-ruhiy va ramziy qatlamlar bilan boyishi ana shu konsepsiyaning badiiy ifodasidir.



5-rasm. Romanlardagi xronotop modellari (konseptual sxema)

M.M.Baxtin nazariyasi nuqtayi nazaridan, Oybek romanida ijtimoiy-tarixiy xronotop – “saroy – shahar” xronotopi yetakchilik qiladi: makon markazga (saroyga) intiluvchi konsentrik tuzilishga ega, zamon esa tarixiy voqealar zanjiri sifatida harakatlanadi. Isajon Sulton romanida esa Baxtin ta’riflagan “yo‘l” xronotopi va biografik zamon unsurlari uyg‘unlashgan “umr yo‘li” xronotopi shakllangan: makon qahramon hayotining bosqichlari bo‘ylab ochiladi, ularni esa ko‘ngil – ichki ma’naviy makon birlashtirib turadi (5-rasm, 3-jadval).

3-jadval

Xronotop modellarining qiyosiy tavsifi

Parametr	“Saroy – shahar” xronotopi (Oybek)	“Umr yo‘li” xronotopi (Isajon Sulton)
Makon tuzilishi	konsentrik, markazga (saroyga) intiluvchi	bosqichma-bosqich ochiluvchi, yo‘l shaklidagi
Zamon turi	ijtimoiy-tarixiy zamon	biografik-ma’naviy zamon
Asosiy konflikt	shaxs va saroy muhiti (tashqi konflikt)	ko‘ngil va dunyo (ichki konflikt), shaxs va muhit (tashqi konflikt)
Qahramon maqomi	davlat arbobi, xalqparvar homiy	shoir-mutafakkir, komil inson
Tarixiylik tamoyili	faktografik aniqlik, keng ijtimoiy panorama	fakt va ramz sintezi, psixologik chuqurlik

Tadqiqot natijalari D.Umaraliyeva [5] va G.Nurullayeva [6] ishlaridagi xulosalarni to‘ldiradi: agar ularda qiyoslash asosan obraz va kompozitsiya darajasida olib borilgan bo‘lsa, ushbu maqolada ikki asar o‘rtasidagi farq xronotop darajasida, ya’ni badiiy olamning makon-zamon asoslari darajasida tizimlashtirildi. Shu bilan birga, tadqiqotning ayrim cheklovlari ham mavjud: makon qatlamlarini baholash sifat mezonlariga asoslangan va muallif talqiniga tayanadi. Kelgusida bu masalani matnning korpus tahlili, xususan, makon va zamon leksikasining miqdoriy tahlili orqali chuqurlashtirish maqsadga muvofiq.

XULOSA

Oybekning “Navoiy” romanida tarixiy zamon qahramon hayotining 1469–1501-yillarini qamrab olgan bo‘lsa, Isajon Sultonning “Alisher Navoiy” romanida bu davr 1441–1501-yillarni, ya’ni mutafakkirning butun umrini o‘z ichiga oladi va natijada tarixiy qamrov qariyb ikki barobar kengaygan. Shu bilan birga, Oybek romanida zamon ijtimoiy-siyosiy voqealar izchilligi asosida tashkil etilgan bo‘lsa, Isajon Sulton romanida “Xazoyin ul-maoniy” devonlarining tuzilishiga muvofiq ravishda umr fasllari tamoyili yetakchilik qiladi.

Asarlarning makon va muhit tasvirida ham o‘ziga xos farqlar mavjud: Oybek romanida real-geografik va ijtimoiy-maishiy makon ustun tursa, Isajon Sulton romanida ichki-ruhiy va ramziy makon muhim o‘rin egallaydi. Bu kabi xususiyatlar ikki romanida ikki xil xronotop modeli shakllanganini ko‘rsatadi: ijtimoiy-tarixiy “saroy – shahar” xronotopi va biografik-ma’naviy “umr yo‘li” xronotopi. Mazkur farqlar Alisher Navoiy obrazi talqinining ijtimoiy-gumanistik yo‘nalishdan ma’naviy-axloqiy (komil inson g‘oyasi) yo‘nalishga tomon siljiganini yaqqol aks ettiradi.

Mazkur tadqiqot natijalaridan oliy ta’lim muassasalari va ixtisoslashtirilgan maktablarning o‘zbek adabiyoti darslarida, shuningdek, tarixiy roman poetikasiga bag‘ishlangan maxsus kurslarda samarali foydalanish mumkin.

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СУНЪИЙ ИНТЕЛЛЕКТ АСОСИДАГИ ИШЛАБ ЧИҚАРИШНИ МОНИТОРИНГ ҚИЛИШ ВА БОШҚАРИШ ТИЗИМИНИ ЖОРИЙ ЭТИШ ҲАМДА УНИНГ САМАРАДОРЛИГИНИ БАҲОЛАШ

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Аннотация. Мақолада тикувчилик корхоналарида ишлаб чиқариш жараёнларини сунъий интеллект (СИ) асосида мониторинг қилиш ва бошқариш тизимининг тўрт қатламли архитектураси, уни босқичма-босқич жорий этиш методикаси ҳамда самарадорликни баҳолаш усули таклиф этилган. Тизим тикув машиналари ҳолатини IoT сенсорлари орқали аниқлаш, машинавий кўриш ёрдамида сифат назорати, унумдорликни прогнозлаш ва оқим линиясини динамик баланслаш модулларини бирлаштиради. Самарадорлик 10 операция ва 19 оператордан иборат тикув линиясининг дискрет-вақтли имитацион моделида ҳар бир сценарий учун 30 сменада баҳоланди. Натижаларга кўра, ускунанинг умумий самарадорлиги (OEE) 52,3 % дан 61,7 % га, сменадаги сифатли маҳсулот ҳажми 17,9 % га ошди, бир машинанинг сменадаги бекор туриш вақти 73 % га қисқарди ($p < 0,001$). Энг катта ҳисса линияни динамик баланслаш модулига тўғри келди.

Калит сўзлар: *сунъий интеллект, тикувчилик, ишлаб чиқариш мониторинги, OEE, линия баланси, IoT, имитацион моделлаштириш, рақамли трансформация.*

КИРИШ

Тўқимачилик ва тикув-трикотаж саноати Ўзбекистон иқтисодиётининг экспортга йўналтирилган етакчи тармоқларидан бири ҳисобланади. «2022–2026 йилларга мўлжалланган Янги Ўзбекистоннинг тараққиёт стратегияси» [1] ва тармоқни ислоҳ қилишга оид қарорлар [2] пахта толасини тўлиқ қайта ишлаш ҳамда юқори қўшилган қийматли тайёр маҳсулот улушини оширишни устувор вазифа сифатида белгилайди. «Рақамли Ўзбекистон — 2030» стратегияси [3] эса ишлаб чиқариш корхоналарида рақамли технологияларни жорий этишни назарда тутади.

Шу билан бирга, аксарият тикувчилик корхоналарида ишлаб чиқариш жараёнларини назорат қилиш ҳалигача қўлда юритиладиган журналлар, смена охиридаги ҳисоботлар ва уста кузатувига асосланади. Натижада машина тўхтаб қолиши, операциялар орасида ярим тайёр маҳсулот тўпланиши («тор жой») ёки нуқсонли маҳсулот кўпайиши ҳақидаги маълумот раҳбариятга кечикиб етиб келади. Тикувчилик ишлаб чиқаришининг меҳнат сиғимли, кўп операцияли ва моделлари тез алмашадиган табиати [9] бу кечикишни айниқса қимматга туширади.

Тикувчиликдаги бошқарув муаммоларининг ўзига хос сабаблари бор. Битта буюм, масалан, кўйлак тайёрлаш 30–60 та қисқа операцияга бўлинади ва ҳар бир операциянинг давомийлиги бир неча сониядан бир неча дақиқагача бўлади. Операторлар малакаси ва иш суръати турлича, моделлар эса буюртмачи талабига кўра бир неча кунда алмашиши мумкин. Шу сабабли линияни бир марта баланслаш билан узоқ муддат барқарор ишлашни таъминлаб бўлмайди. Ишлаб чиқариш устаси ҳар доим «қаерда иш тўпланиб қолди», «қайси машина тўхтади» ва «қайси операцияда нуқсон кўпайди» деган саволларга тезкор жавоб излашга мажбур. Анъанавий бошқарувда бу саволларга жавоб устанинг тажрибаси ва кузатувига боғлиқ бўлиб қолади.

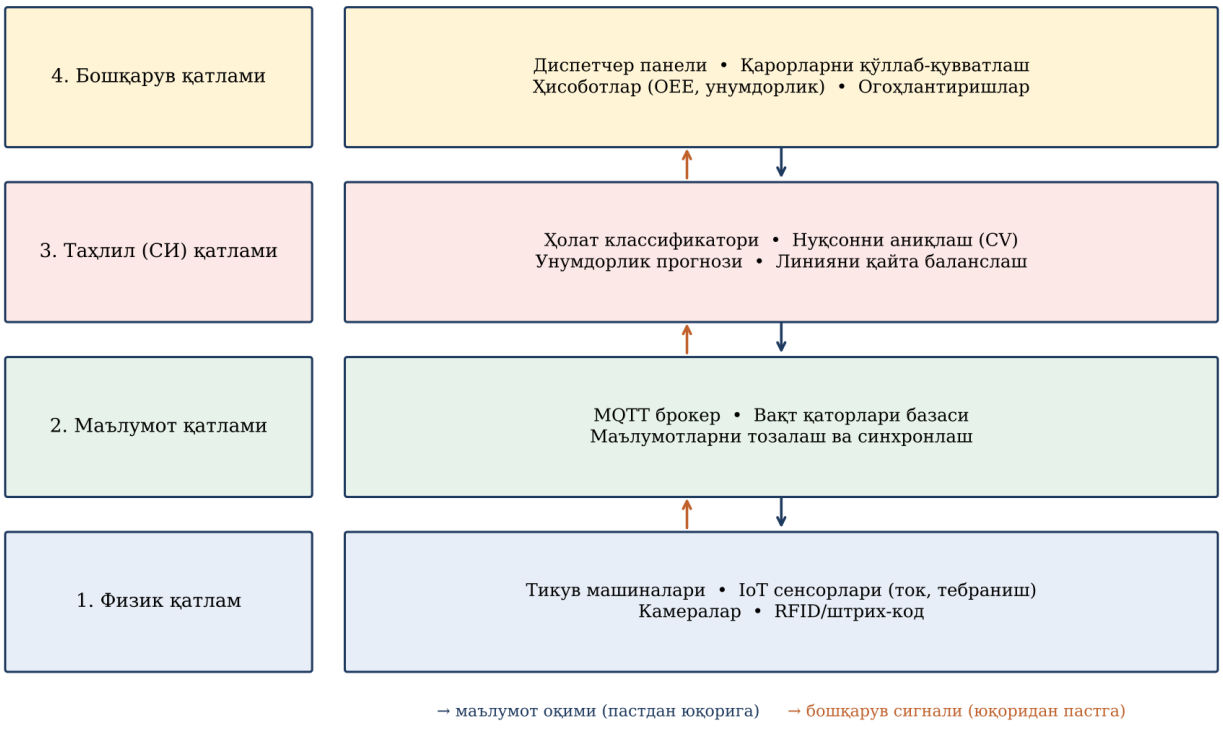
Индустрия 4.0 концепцияси [4] ва кибер-физик тизимлар архитектураси [5] физик жараёнлардан реал вақтда маълумот йиғиш, уни таҳлил қилиш ва бошқарув қарорларини автоматлаштиришни назарда тутади. Ишлаб чиқаришда чуқур ўқитиш [6] ва маълумотларга асосланган «ақлли» ишлаб чиқариш [7, 8] бўйича

тадқиқотлар СИ усулларининг ускуна ҳолатини ташхислаш, сифат назорати ва режалаштиришдаги самарасини кўрсатган. Тикувчилик соҳасида RFID асосида ресурсларни тақсимлаш тизими [10] ва автоматлаштириш бўйича тадқиқотлар [9] мавжуд. Бироқ мониторинг, сифат назорати ва оқим линиясини бошқаришни ягона СИ тизимида бирлаштириш ҳамда бундай тизимни жорий этиш самарадорлигини миқдорий баҳолаш масаласи етарлича ўрганилмаган.

Тадқиқот мақсади — СИ асосидаги ишлаб чиқаришни мониторинг қилиш ва бошқариш тизимини жорий этиш методикасини ишлаб чиқиш ва унинг самарадорлигини миқдорий баҳолаш. Мақсадга эришиш учун қуйидаги вазифалар қўйилди: (1) тизимнинг функционал архитектурасини асослаш; (2) жорий этиш босқичларини белгилаш; (3) самарадорлик кўрсаткичлари тизимини танлаш; (4) имитацион модел ёрдамида тизимнинг умумий самарасини ва ҳар бир модулнинг ҳиссасини баҳолаш.

УСУЛЛАР

Тизим архитектураси. Таклиф этилаётган тизим кибер-физик тизимлар концепцияси [5] асосида тўрт қатламли қилиб лойиҳаланди (1-расм). Физик қатламда тикув машиналарига ток ва тебраниш сенсорлари, иш ўринлари устига камералар ўрнатилади, ярим тайёр маҳсулот пачкалари эса штрих-код ёки RFID ёрлиқлари орқали кузатилади. Маълумот қатлами сенсорлардан келаётган оқимни MQTT протоколи орқали қабул қилади, тозалайди ва вақт қаторлари базасида сақлайди. Таҳлил қатламида СИ моделлари ишлайди, бошқарув қатлами эса натижаларни диспетчер панели, огоҳлантиришлар ва қарор таклифлари кўринишида устага ҳамда цех раҳбарига етказади.



1-расм. СИ асосидаги мониторинг ва бошқариш тизимининг тўрт қатламли архитектураси

СИ модуллари. Таҳлил қатлами тўртта модулдан иборат. *Ҳолат классификатори* ток ва тебраниш сигналларининг 1 секундлик ойналаридан олинган статистик белгилар асосида машинанинг «ўчиқ», «бўш туриш», «тикиш» ва «носозлик» ҳолатларини тасодифий ўрмон (Random Forest) алгоритми [17] ёрдамида аниқлайди. *Сифат назорати модули* иш ўрни камераси тасвирларида чок нуқсонларини YOLO оиласидаги бир босқичли детектор [14] ёрдамида топади ва нуқсонни уни келтириб чиқарган операцияга боғлайди. *Прогноз модули* соатлик унумдорликни LSTM тармоғи [15] ёки градиент бустинг (XGBoost) [16] ёрдамида олдиндан

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баҳолайди. *Баланслаш модули* операциялар ўтказиш қобилиятини ҳисоблаб, мослашувчан операторни «тор жой»га кўчиришни таклиф қилади.

Модулларнинг кириш маълумотлари, алгоритмлари ва иш даврийлиги 1-жадвалда умумлаштирилган. Модуллар бир-бирига боғлиқ: ҳолат классификатори натижалари прогноз ва баланслаш модуллари учун кириш маълумоти бўлиб хизмат қилади.

1-жадвал

Тизимнинг СИ модуллари тавсифи

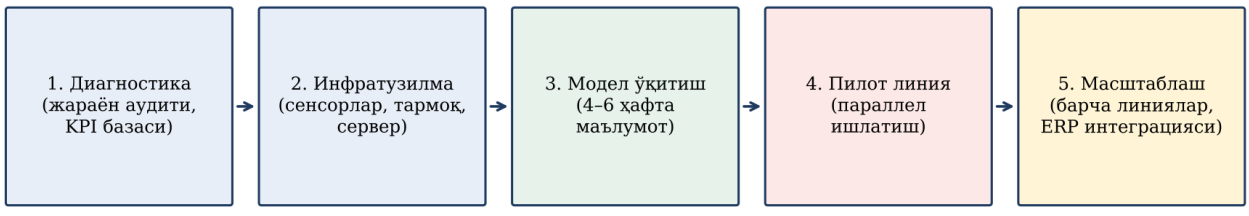
Модул	Кириш маълумоти	Алгоритм	Даврийлик	Чиқиш
Ҳолат классификатори	Ток ва тебраниш белгилари (1 с)	Random Forest	1 с	Машина ҳолати, бекор туриш
Сифат назорати	Иш ўрни тасвирлари	YOLO детектори	Ҳар буюм	Нуқсон тури ва операция
Унумдорлик прогнози	Соатлик чиқиш, ҳолатлар тарихи	LSTM / XGBoost	15 дақ	Кейинги соат чиқиши
Линияни баланслаш	SMV, e_k, буферлар	Очкўз эвристика	60 дақ	Операторни кўчириш тавсияси

Баланслаш масаласи қуйидагича ифодаланди. *i*-операциянинг ўтказиш қобилияти:

$$c_i = \sum \frac{ek}{SMV_i}, \quad k \in K_i \qquad (1)$$

бу ерда K_i — *i*-операцияга бириктирилган операторлар тўплами, e_k — *k*-операторнинг жорий самарадорлик коэффициенти, SMV_i — операциянинг стандарт вақти (дақ/дона). Линия чиқиши энг кичик c_i билан чекланганлиги сабабли, модул ҳар соатда $\max \min_i c_i$ мезонини яхшилайдиган битта операторни қайта тақсимлашни танлайди (очкўз алгоритм). Бу ёндашув ҳисоблаш жиҳатдан енгил бўлиб, устага тушунарли тавсия беради.

Жорий этиш методикаси. Тизимни корхонага жорий этиш беш босқичда амалга оширилади (2-расм). Биринчи босқичда жараён аудити ўтказилиб, KPI нинг бошланғич қийматлари қайд этилади. Иккинчи босқичда сенсорлар, тармоқ ва сервер инфратузилмаси ўрнатилади. Учинчи босқичда камида 4–6 ҳафталик маълумот асосида моделлар ўқитилади. Тўртинчи босқичда пилот линияда тизим тавсиялари анъанавий бошқарув билан параллел синалади. Бешинчи босқичда тизим барча линияларга кенгайтирилади ва корхона ERP тизими билан интеграция қилинади.



2-расм. Тизимни корхонага жорий этиш босқичлари

Самарадорлик кўрсаткичлари. Асосий интеграл кўрсаткич сифатида ускунанинг умумий самарадорлиги (OEE) [11, 12] қабул қилинди:

$$OEE = A \times P \times Q \qquad (2)$$

бу ерда A — фойдаланиш имконияти (режалаштирилган вақтдан бекор туриш чегириб ташланган улуш), P — самарадорлик, Q — сифат коэффициенти. Тикувчиликда P кўрсаткичи стандарт вақт (SAM) усулида линия самарадорлиги сифатида ҳисобланди: $P = N \cdot \Sigma SMV / (n \cdot T \cdot A)$, бу ерда N — чиқарилган маҳсулот, n —

операторлар сони, T — смена давомийлиги. Кўрсаткичлар тизими ISO 22400-2 стандарти [13] тавсияларига мос равишда 2-жадвалда келтирилган.

2-жадвал

Самарадорликни баҳолаш кўрсаткичлари тизими

Кўрсаткич	Ҳисоблаш формуласи	Ўлчов бирлиги	Маълумот манбаи
Фойдаланиш имконияти (A)	$\frac{T - T_{\text{бекор}}}{T}$	%	Ҳолат классификатори
Линия самарадорлиги (P)	$N \times \sum \frac{SMV}{n \times T \times A}$	%	Пачка ҳисоби, SMV базаси
Сифат коэффициенти (Q)	$N_{\text{сифатли}} / N$	%	CV модули, назоратчи
OEE	A × P × Q	%	Ҳисобланади
Сифатли маҳсулот	$N_{\text{сифатли}}$	дона/смена	Пачка ҳисоби
Бекор туриш вақти	$\sum \frac{T_{\text{бекор}}}{n}$	дақ/машина	Ҳолат классификатори

Имитацион модел ва тажриба дизайни. Тизимнинг самарасини реал корхонада синашдан олдин баҳолаш учун тикув оқим линиясининг дискрет-вақтли имитацион модели [18] Python тилида тузилди. Модел 1 дақиқалик қадам билан ишлайди: ҳар қадамда ҳар бир операциянинг ўтказиш қобилияти фаол машиналар ва операторлар самарадорлиги бўйича ҳисобланади, ярим тайёр маҳсулот операциялар орасидаги буферлар орқали ҳаракатланади. Машина бузилишлари Пуассон оқими, аниқлаш кечикиши ва таъмир давомийлиги эса экспоненциал тақсимот билан моделлаштирилди. Модел параметрлари 3-жадвалда келтирилган.

3-жадвал

Имитацион модел параметрлари

Параметр	Анъанавий бошқарув	СИ асосидаги тизим
Операциялар / операторлар сони	10 / 19	10 / 19
Буюм стандарт вақти, ΣSMV	11,2 дақ	11,2 дақ
Оператор самарадорлиги, e_k	N(0,82; 0,08)	N(0,82; 0,08)
Бузилишлар жадаллиги	0,45 / машина·смена	0,29 / машина·смена
Носозликни аниқлаш кечикиши (ўрт.)	12 дақ	1,5 дақ
Таъмир давомийлиги (ўрт.)	10 дақ	8 дақ
Линияни баланслаш	Смена бошида, статик	Ҳар соатда, динамик
Нуқсон улуши (ўрт.)	4,2 %	2,5 %
Смена / такрорлар сони	480 дақ / 30	480 дақ / 30

СИ сценарийсидаги параметрлар қуйидаги фаразларга асосланади: реал вақтли ҳолат мониторинги аниқлаш кечикишини бир неча дақиқагача камайтиради; олдиндан огоҳлантирувчи техник хизмат бузилишлар сонини тахминан учдан бирга қисқартиради; нуқсонни у пайдо бўлган операцияда тезкор аниқлаш нуқсон улушини пасайтиради. Иккала сценарий учун ҳам бир хил тасодифий сонлар кетма-кетлиги (common random numbers) ишлатилди, бу фарқни фақат бошқарув усули билан изоҳлаш имконини беради. Натижалар Уэлч t-мезони ёрдамида солиштирилди. Ҳар бир модулнинг алоҳида ҳиссасини аниқлаш учун модуллар навбатма-навбат ёқилган қўшимча сценарийлар (абляция таҳлили) ҳам ҳисобланди.

НАТИЖАЛАР

Иккала сценарий бўйича 30 сменалик моделлаштиришнинг асосий натижалари 4-жадвалда келтирилган. СИ асосидаги тизим барча кўрсаткичлар бўйича анъанавий бошқарувдан устун келди.

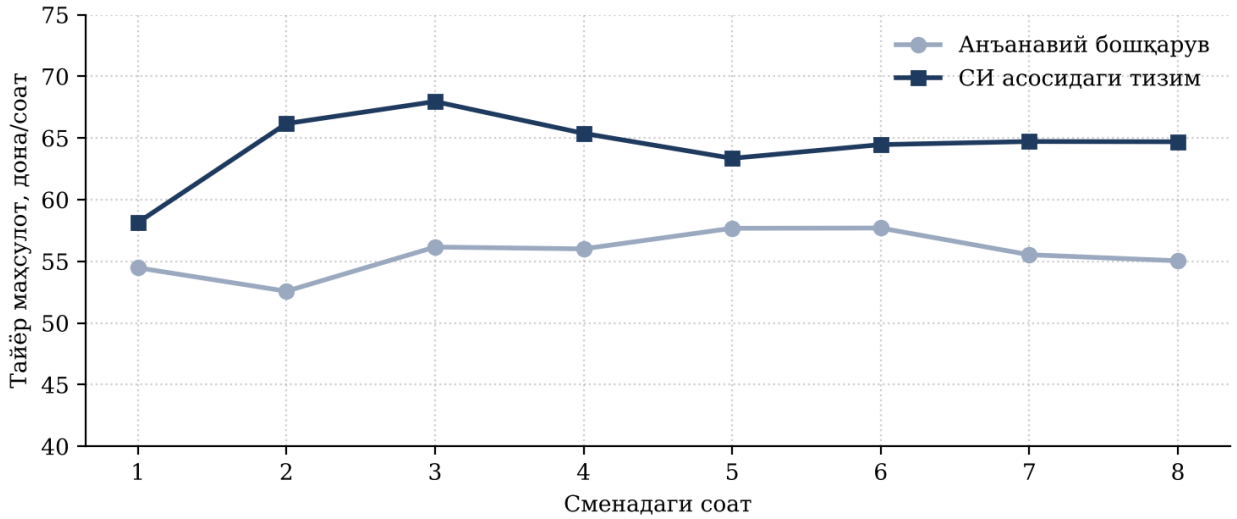
4-жадвал

Имитацион моделлаштиришнинг асосий натижалари (ўртача ± ст. оғиш, n = 30 смена)

Кўрсаткич	Анъанавий	СИ асосидаги	Ўзгариш
Жами маҳсулот, дона/смена	445,2 ± 42,2	514,8 ± 24,5	+15,6 %
Сифатли маҳсулот, дона/смена	426,2 ± 40,9	502,6 ± 24,3	+17,9 %
Фойдаланиш имконияти A, %	98,1 ± 0,7	99,5 ± 0,3	+1,4 ф.б.
Линия самарадорлиги P, %	55,7 ± 5,2	63,6 ± 3,1	+7,9 ф.б.
Сифат коэффициенти Q, %	95,7 ± 0,5	97,6 ± 0,5	+1,9 ф.б.
OEE, %	52,3 ± 5,0	61,7 ± 3,0	+9,4 ф.б.
Бекор туриш, дақ/машина·смена	9,3 ± 3,3	2,5 ± 1,2	−73,3 %

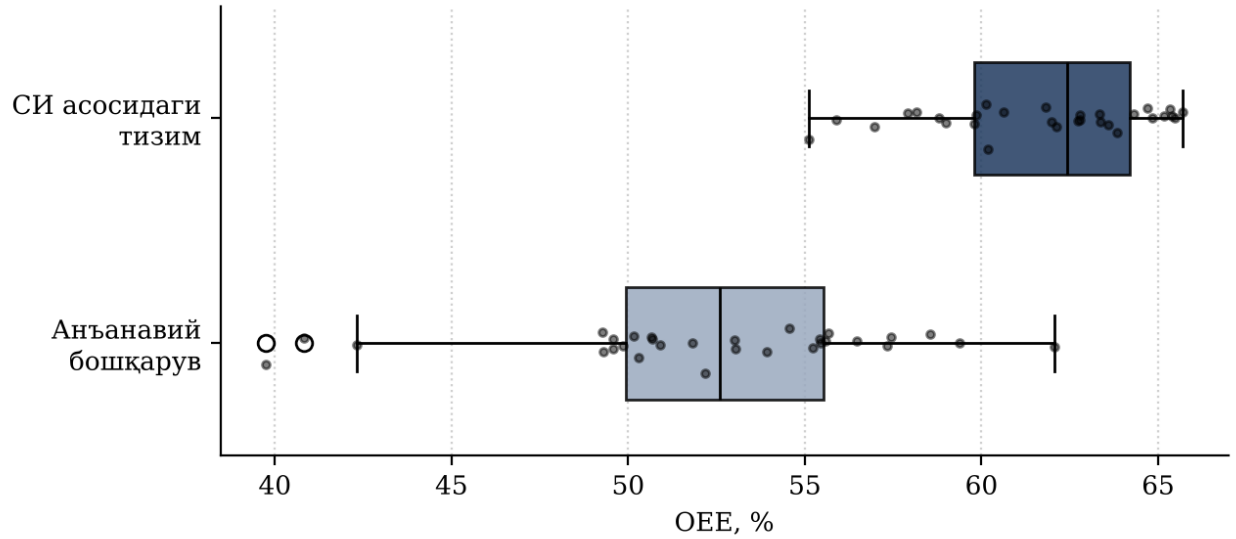
OEE бўйича фарқ статистик жиҳатдан аҳамиятли: Уэлч мезони $t = 8{,}65$ (эркинлик даражаси ≈ 47), $p < 0{,}001$. Сифатли маҳсулот ҳажмининг стандарт оғиши ҳам 40,9 дан 24,3 донагача, яъни қарийб 40 % га камайди. Бу тизим нафақат ўртача унумдорликни оширишини, балки сменалар орасидаги натижалар барқарорлигини ҳам таъминлашини кўрсатади.

Соатлик чиқиш динамикаси (3-расм) иккала сценарийда ҳам биринчи соат линияни ярим тайёр маҳсулот билан тўлдириш даври эканини кўрсатади. Кейинги соатларда анъанавий бошқарувда чиқиш 53–58 дона/соат оралиғида қолган бўлса, СИ тизимида биринчи қайта баланслашдан сўнг 63–68 дона/соат даражасига кўтарилди.



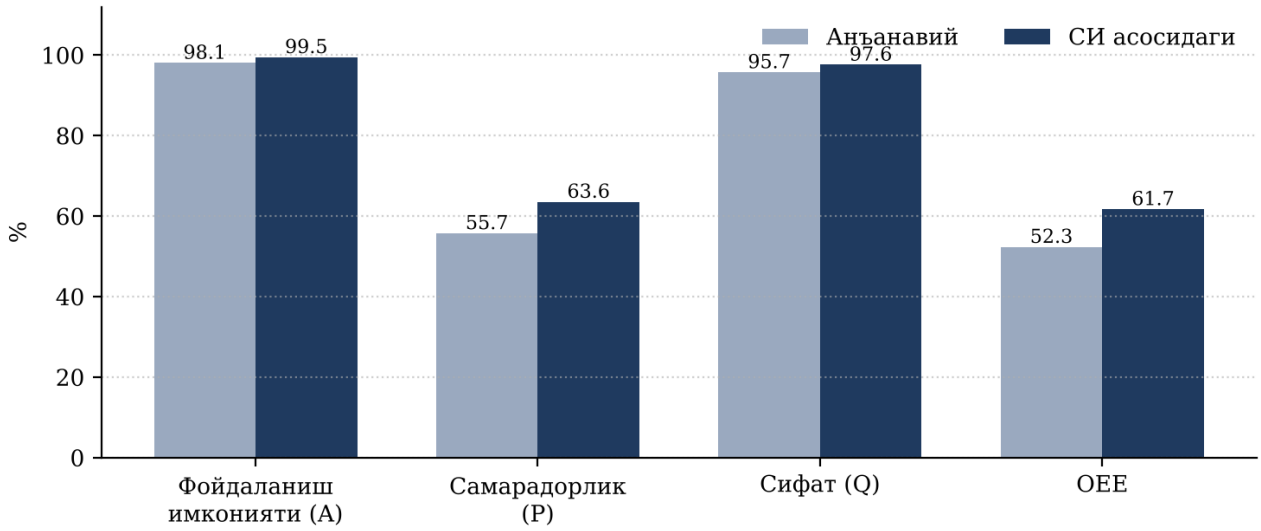
3-расм. Сменадаги соатлик сифатли маҳсулот чиқиши (30 сменанинг ўртачаси)

OEE нинг сменалар бўйича тақсимоти (4-расм) СИ сценарийсида натижалар тарқоқлиги анча кичик эканини ва энг паст сменалар ҳам анъанавий бошқарувнинг ўртача даражасидан юқори бўлганини кўрсатади.



4-расм. OEE нинг 30 смена бўйича тақсимоти (нуқталар — алоҳида сменалар)

OEE ташкил этувчилари бўйича таҳлил (5-расм) ўсишнинг асосий манбаи самарадорлик (P) эканини кўрсатди. Фойдаланиш имконияти иккала ҳолатда ҳам юқори бўлгани учун унинг ўсиши нисбатан кичик (+1,4 ф.б.). Лекин машина тўхташи унга боғлиқ кейинги операцияларни ҳам «оч» қолдиргани учун бекор туришнинг қисқариши билвосита P га ҳам таъсир қилади.



5-расм. OEE ташкил этувчиларининг сценарийлар бўйича қиёсий таҳлили

Модулларнинг алоҳида ҳиссаси абляция таҳлили натижаларида кўрсатилган (5-жадвал, 6-расм). Ҳар бир модул алоҳида ёқилганда OEE нинг ўсиши: мониторинг ва олдиндан огоҳлантирувчи хизмат — 2,6 ф.б., динамик баланслаш — 5,7 ф.б., CV асосидаги сифат назорати — 1,0 ф.б. Уларнинг йиғиндиси (9,3 ф.б.) тўлиқ тизим самарасига (9,4 ф.б.) деярли тенг, яъни модуллар бир-бирининг таъсирини камайтирмайди ва асосан аддитив ишлайди.

5-жадвал

Тизим модулларининг ҳиссаси (абляция таҳлили, 30 смена ўртачаси)

Сценарий	Сифатли маҳсулот, дона	A, %	P, %	Q, %	OEE, %
Анъанавий бошқарув	426,2	98,1	55,7	95,7	52,3
+ Мониторинг ва прогнозли хизмат	446,9	99,5	57,5	95,9	54,9
+ Динамик баланслаш	472,4	98,1	61,8	95,7	58,0
+ CV сифат назорати	433,8	98,1	55,7	97,4	53,3
Тўлиқ СИ тизими	**502,6**	**99,5**	**63,6**	**97,6**	**61,7**

СИ сценарийсидаги параметрлар фаразий бўлгани учун натижаларнинг уларга сезгирлиги текширилди (6-жадвал). Пессимистик сценарийда носозликни аниқлаш кечикиши 5 дақиқа, бузилишлар фақат 15 % га камаяди ва нуқсон улуши 3,5 % деб олинди. Оптимистик сценарийда эса бу қийматлар мос равишда 1 дақиқа, 50 % ва 2,0 %. Ҳатто пессимистик фаразларда ҳам OEE 7,7 ф.б. га, сифатли маҳсулот 14,6 % га ошди. Демак, тизим самарасининг асосий қисми фаразларнинг аниқ қийматига кам боғлиқ.

6-жадвал

Натижаларнинг модел фаразларига сезгирлиги (тўлиқ СИ тизими, 30 смена)

Сценарий	Сифатли маҳсулот, дона	Ўсиш, %	OEE, %	Бекор туриш, дақ
Анъанавий (таққослаш)	426,2	—	52,3	9,3
Пессимистик	488,5	+14,6	60,0	4,3
Асосий	502,6	+17,9	61,7	2,5
Оптимистик	505,7	+18,6	62,1	1,9

Иқтисодий самарани баҳолаш учун бир линия бўйича қўшимча сифатли маҳсулот ҳажми асос қилиб олинди. Ҳисоб-китоб тартиби 7-жадвалда берилган. Маржинал фойда ва тизим харажатлари корхонага хос бўлгани учун улар ўзгарувчи сифатида қолдирилди.

7-жадвал

Бир линия бўйича иқтисодий самарани ҳисоблаш тартиби

Кўрсаткич	Формула	Қиймат
Қўшимча сифатли маҳсулот, дона/смена	$\Delta N = N_{СИ} - N_{анъан}$	76,4
Ойлик қўшимча маҳсулот (22 иш куни, 1 смена)	$\Delta N_{ой} = 22 \times \Delta N$	≈ 1 681
Йиллик қўшимча фойда	$\Delta Ф = 12 \cdot \Delta N_{ой} \cdot m$	m — 1 дона маржинал фойда
Ўзини қоплаш муддати, ой	$Тқ = K / (\Delta Ф/12 - Э)$	K — инвестиция, Э — ойлик хизмат харажати

МУҲОКАМА

Олинган натижалар СИ тизимининг асосий самараси алоҳида «ақлли» функциялардан эмас, балки мониторинг маълумотлари асосида оқимни тезкор бошқаришдан келиб чиқишини кўрсатади. Абляция таҳлилида динамик баланслаш модули умумий ўсишнинг қарийб 60 % ини таъминлади. Бу тикувчилик линиясининг ўзига хослиги билан изоҳланади: операторлар самарадорлиги кун давомида ва ҳар хил бўлади, шу сабабли смена бошида тузилган статик баланс тезда эскиради. Реал вақтли маълумот бўлмаса, уста «тор жой»ни кўз билан, кўпинча кечикиб аниқлайди.

Мониторинг модулининг ҳиссаси нисбатан кичик бўлиб чиқди (2,6 ф.б.). Бунга моделда бузилишлар жадаллиги паст олингани сабаб бўлди. Эскирган машина паркига эга корхоналарда бу модулнинг аҳамияти ортади. Бундан ташқари, мониторинг маълумотлари бошқа модуллар учун ҳам асос бўлади: ҳолат классификатори бўлмаса, баланслаш модули операторларнинг жорий самарадорлигини билолмайди. Шу маънода модуллар техник жиҳатдан аддитив бўлса-да, ахборот жиҳатидан бир-бирига боғлиқ.

CV асосидаги сифат назоратининг OEE га бевосита таъсири кам бўлди (1,0 ф.б.), аммо унинг аҳамияти бу кўрсаткич билан чекланмайди. Нуқсонни у пайдо бўлган операцияда аниқлаш қайта ишлаш харажатларини, буюртмачи шикоятлари хавфини ва экспорт шартномаларидаги жарима рискини камайтиради. Бу самаралар OEE да акс этмайди. Улар алоҳида баҳоланиши лозим.

Сезгирлик таҳлили яна бир муҳим хулосани берди: оптимистик ва асосий сценарийлар орасидаги фарқ жуда кичик (OEE бўйича 0,4 ф.б.). Демак, носозликни аниқлаш кечикишини бир неча дақиқадан янада камайтириш катта қўшимча самара бермайди. Бу ҳолат мониторинги учун қиммат юқори частотали тизимлар шарт эмаслигини, арзон IoT сенсорлари етарли эканини кўрсатади. Аксинча, пессимистик сценарийда самара сезиларли пасаяди. Бу эса огоҳлантириш устага етиб бориши ва унга жавоб қайтариш тартиби, яъни ташкилий жараён тизимнинг техник қисми каби муҳим эканини билдиради.

Тизимнинг бошқарувдаги ўрнини «маълумот — таҳлил — қарор — ҳаракат» цикли сифатида қараш мумкин. Анъанавий бошқарувда бу цикл смена ёки кун давомида бир марта ёпилади, СИ тизимида эса дақиқалар ичида. Бироқ охирги бўғин — ҳаракат — ҳалигача инсон томонидан бажарилади: операторни кўчириш ёки машинани таъмирлаш ҳақидаги қарорни уста қабул қилади. Шу сабабли тизим автоматик бошқарувчи эмас, балки қарор қабул қилишни қўллаб-қувватловчи восита сифатида лойиҳаланди. Бу ёндашув жорий этишда ходимлар қаршилигини камайтиради ва масъулиятни аниқ сақлаб қолади.

Тадқиқотнинг чекловлари қуйидагилардан иборат. *Биринчидан*, натижалар имитацион моделга асосланган ва СИ сценарийсидаги параметрлар (аниқлаш кечикиши, бузилишлар ва нуқсонларнинг камайиши) фаразий қийматлардир. Уларни реал корхонада пилот синов ўтказиб аниқлаштириш зарур. *Иккинчидан*, моделда операторларнинг ўрганиш эффекти, чарчаши ва бир операциядан бошқасига ўтишдаги мослашиш вақти ҳисобга олинмаган. *Учинчидан*, тизимни жорий этишнинг ижтимоий жиҳатлари — операторларнинг кузатувга муносабати ва ходимлар ҳақидаги маълумотлар махфийлиги — алоҳида тартибга солишни талаб қилади. Тизим маълумотларидан жазолаш учун эмас, балки жараённи яхшилаш учун фойдаланиш тамойилини корхона ички низомида мустаҳкамлаш тавсия этилади.

Амалий тавсия сифатида тизимни бир йўла эмас, балки 2-расмда кўрсатилган босқичлар бўйича жорий этиш таклиф қилинади. Абляция натижаларига кўра, чекланган бюджетли корхоналар учун энг юқори самарани ҳолат мониторинги ва динамик баланслаш модуллари беради. CV модулини эса кейинги босқичда, нуқсон улуши юқори бўлган операциялардан бошлаб жорий этиш мумкин.

ХУЛОСА

Тадқиқот натижасида тикувчилик корхоналари учун СИ асосидаги ишлаб чиқаришни мониторинг қилиш ва бошқариш тизимининг тўрт қатламли архитектураси, беш босқичли жорий этиш методикаси ва OEE га асосланган самарадорлик кўрсаткичлари тизими ишлаб чиқилди. Имитацион моделлаштириш тизим OEE ни 52,3 % дан 61,7 % гача, сифатли маҳсулот чиқишини 17,9 % га оширишини ва машиналарнинг бекор туриш вақтини 73 % га қисқартиришини кўрсатди. Бунда сменалараро натижалар барқарорлиги ҳам сезиларли яхшиланади. Энг катта самарани оқим линиясини динамик баланслаш модули беради. Кейинги тадқиқотлар тизимни реал корхонада пилот синовдан ўтказиш, модел параметрларини амалий маълумотлар асосида калибрлаш ва иқтисодий самарани аниқ ҳисоблашга қаратилади.

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