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Content

Agricultural sciences

- Neamt Radu, Dragomir Neculai, Neciu Florin, Saplacan Gheorghe, Mihali Ciprian, Mizeranschi Alexandru, Saplacan Silviu, Csiszter Ludovic, Anton Andreea* 4
RESEARCH REGARDING THE BALANCE OF "RAW-NET CO₂ EQ" IN THE FARM CROPS

Astronomy

- Vladimir V. Tchernyi, Sergey V. Kapranov* 11
HOW SATURN CREATED STABLE VISIBLE DENSE RINGS USING GRAVITY AND ITS MAGNETIC FIELD. A MATHEMATICAL EXAMINATION

Economic sciences

- Asmat Shamugia* 15
CORPORATE SOCIAL RESPONSIBILITY OF MANAGERS
- Ibrayeva A.R., Zhelyu Vladimirov* 18
QUALIFICATION ADAPTATION OF THE WORKFORCE TO THE NEEDS OF THE REGIONAL LABOR MARKET: THE CASE OF THE KARAGANDA REGION
- Sonela Stillo, Gentisa Furxhi* 25
THE IMPORTANCE OF ETHICAL PRACTICES AND THEIR APPLICABILITY IN THE PUBLIC AND THE PRIVATE SECTOR IN THE KORCA REGION
- Valiyev Orkhan Mubariz* 32
REGIONAL ASPECTS OF THE DEVELOPMENT OF THE ALTERNATIVE ENERGY SECTOR IN AZERBAIJAN (IN THE LIBERATED TERRITORIES)

Medical sciences

- Arman Khozhayev, Zhansaya Zhazykbay, Gauhar Zhussip, Zhansaya Myrzakhmet, Ayazhan Zhumabek, Diana Baimukhametova, Gulnaz Khalitova, Akerkem Kaishybay, Arailym Syzdykova* 38
RETINOBLASTOMA: THE STATUS OF THE PROBLEM AND POSSIBILITIES FOR ITS SOLUTION
- Panov Stanislav I.* 50
MORPHOFUNCTIONAL CHARACTERISTICS OF THE LIVER IN FULL-TERM NEONATES: MORPHOMETRIC PROFILE, EXTRACELLULAR MATRIX PROTEIN EXPRESSION, AND EVALUATION OF NON-INVASIVE FIBROSIS BIOMARKERS
- Begimbetov Z.T., Ubaydayeva A.B., Mamyraymov E.B.* 53
MORPHOLOGICAL CHARACTERISTICS OF SMALL INTESTINAL POLYPS AMONG RESIDENTS OF THE SOUTHERN REGION OF KAZAKHSTAN
- Arman Khozhayev, Guldana Taubayeva, Aray Turarova, Shynar Khamzina, Ayaulym Ismagali, Akerke Yeralbek, Tomiris Nurakhmetova, Zhanat Zhienbaeva, Diana Aubekova* 58
THYROID CANCER: MODERN CLINICAL AND DIAGNOSTIC CONCEPT

Pedagogical sciences

- Inna Robertovna Sargsyan* 66
A MODEL OF A MODERN RUSSIAN LANGUAGE TEXTBOOK FOR UNIVERSITIES OF THE REPUBLIC OF ARMENIA

Physical sciences

- Antonov A.A.* 71
TIME TRAVELS IS NOW PHYSICALLY POSSIBLE

Political sciences

- Kostiuk Tetiana, Skoropad Artur* 89
TRANSFORMATION OF SECURITY DIPLOMACY IN EUROPE 1945 – 2024
- Haitbayeva Shaira Kadyrovna, Geldiyev Kerimguly, Kadyrov Ilyas* 101
PROSPECTS FOR THE IMPLEMENTATION OF JOINT PROJECTS IN THE FIELD OF SUSTAINABLE DEVELOPMENT BETWEEN INDEPENDENT AND NEUTRAL TURKMENISTAN AND THE FRENCH REPUBLIC

Technical sciences

<i>Guliyev Asif Humbat, Azammadov Nurlan Rasul</i> EXPERIMENTAL STUDY OF HYDRAULIC RESISTANCES IN PIPES MADE OF PARALLEL JOINTED PLASTIC MASS USED IN TRANSPORTATION OF OIL AND OIL PRODUCTS	106
<i>Guliyev Asif Humbat, Murtuzaliyev Ramazan Afgan</i> STUDY OF HYDRAULIC RESISTANCES IN CONTINUOUSLY JOINTED NON-METALLIC PIPES USED IN OIL FIELD EQUIPMENT	116
<i>Guliyev Asif Humbat, Rahmanov Raji Tajaddin</i> RESEARCH OF THE DEPENDENCES BETWEEN THE MAIN PARAMETERS OF A HYDROCYLINDER ENGINE OPERATING IN DIFFERENT LOAD MODES	122
<i>Rustam Bagirov, Yasin Khalilov, Sevinj Akbarova, Vasif Shahmarov</i> STUDY OF THE EFFECT OF VOLCANO ASH ON THE PROPERTIES OF CEMENT-BASED DRY CONSTRUCTION MIXTURES	128
<i>Zhandos Akhmetov, Shynggys Galipauly, Gulzada Koishina, Yeleussiz Tazhiyev, Aliya Alimzhanova</i> EVALUATION OF MAGNETIC SEPARATION EFFICIENCY FOR INCREASING IRON CONTENT IN TITANOMAGNETITE ORES OF THE TYMLAISKY DEPOSIT	133

Agricultural sciences

RESEARCH REGARDING THE BALANCE OF "RAW-NET CO₂ EQ" IN THE FARM CROPS -CASE STUDY-

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Methodology and Background

The aim of the current study was to assess the balance of raw-net CO₂ eq from the usually farm crops. The research activity, based on the realization of numerous analyses, determinations and studies of an economic nature, was performed in the agricultural bio base of the Research and Development Station for Bovine Arad, Romania during the year 2024. The structure of the fodder system of this farm included the following crops:

- concentrated fodder crops (585 ha-57%)
- grain wheat 335 ha-33%),
- grain corn (150 ha-14%),
- grain barley (100 ha-10%)
- green fodder crops (178 ha-18%)-
- alfalfa (79 ha-8%),
- perennial grasses (58 ha-5%),
- Sudan grass (22 ha-2%),
- autumn gorse (15 ha-2%),
- mix of alfalfa with perennial grasses (4 ha-1%)
- ensilaged fodder crops (256 ha-25%)
- corn silage (256 ha-25%)

The results of the conducted studies aimed at the following objectives:

-the amount of "raw" C-CO₂ eq captured through photosynthesis and fixed in the biomass of crops in the feed system- the carbon footprint according to agrotechnical works applied to carry out the germinal, fertilization, maintenance, harvesting and transport operations

-the amount of "net" carbon fixed and the general distribution of carbon fixed through photosynthesis, at the level of the forage system- the total amount of "net" carbon fixed through photosynthesis at the level of the forage system

I. The amount of "raw" C-CO₂ eq captured through photosynthesis and fixed in the biomass of crops in the feed system- the carbon footprint according to agrotechnical works applied to carry out the germinal, fertilization, maintenance, harvesting and transport operations.

The synthesis of research results from recent decades on the situation of global GHG emissions shows that, on average, their quantitative value increased from 10 million tons CO₂ eq in 1750 to 35 billion tons in 2020. The share of GHG emissions at global level, by gas structure is as follows: 65% fossil CO₂ and industrial processes), 11% CO₂ agricultural work, 16% CH₄, 6% NO₂ and 2% other gases. By economic sector of origin, the share of GHG emissions at global level is given by 25% energy sector, 24% agricultural and forestry sector, 21% industrial sector, 14% transport sector, 6% construction sector, 10% other sectors. According to EUROSTAT, at the level of EU countries, GHG emissions amount to 4323163 kilotons of CO₂ eq. In this case, Romania's contribution is only 2% while having a huge carbon

storage potential of approx. 22 Gt CO₂ eq. The increase in atmospheric CO₂ concentration is strongly correlated with a sharp reduction in nutrients in agricultural crops, by up to 20%, in the coming decades. Thus, a reduction in the content of plant proteins and essential microelements in human and animal nutrition (Fe, Zn) is expected. Despite all measures to reduce GHGs, research conducted at Harvard University shows that by 2050, the concentration of CO₂ in the atmosphere will increase by 35%, from the current 405 ppm to 550 ppm. In Romania, depending on the structure of agricultural crops and the technology applied, soil carbon losses vary between 200-300 kg/ha/year, while permanent grasslands store between 300-500 kg C/ha/year.

In this respect, we present the results obtained through this research on quantifying the amount of carbon fixed in the biomass of fodder species in the agricultural system implemented in the current study.

Table 1 The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of the wheat grain crop

Wheat grain biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Grain production	4,61	1542	41	1,28	32	1890	633 (42%)	6917	2317
Root production	6,6	2211	24,5	0,42	58,3	1617	542 (36%)	5918	1984
Straw production	2,14	719	37,1	0,68	54,5	794	266 (18%)	2906	974
Stubble production	0,49	164	38,4	0,53	72,4	188	63(4%)	688	231
Total	13,84	4636	-	-	54,3	4489	1504 (100%)	16429	5506

From the data presented in the table, it is found that, in the case of wheat crop, the amount of carbon fixed through photosynthesis varies depending on the production structure. Thus, the highest content of fixed carbon is found in grain production, recording a quantity of 1890 kg/ha or a total of 633 t, on a cultivated area of 335 ha. Compared to the total amount of fixed carbon of 1504 t, grain production fixes carbon in a share of 42%. Root production fixes an amount of 1617 kg C/ha, respectively 36% of the total amount of fixed carbon. Plant residues (straw, stubble) fix smaller amounts of carbon, respectively 794 kg/ha (18% of the total) in the case of straw production and 188 kg/ha (4% of the total) for stubble production. The cumulative amount of fixed carbon in the case of wheat crop is 4489 kg/ha (16429 kg/ha CO₂ eq) and a total amount, related to the cultivated area, of 1504 t fixed carbon (5506 t CO₂ eq).

The intensity of the decomposition rate of secondary production (straw, stubble) and of roots, which are part of the organic matter in the soil, is low (with C/N ratio values between 54.5-72.4).

Table 2. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of the corn grain crop (150 ha)

Corn grain biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Grain production	4,7	705	41	1,28	32	1927	289 (43%)	7053	1058
Strains production	5,7	855	38,8	1,26	30,8	2212	332 (50%)	8095	1215
Root production	0,8	120	37,4	1,22	30,7	299	45 (7%)	1094	165
Total	11,2	1680	-	-	-	4438	666 (100%)	16242	2438

The corn grain crop captures through photosynthesis and fixes in the total biomass a quantity of carbon of 4438 kg/ha, respectively 16242 kg/ha CO₂ eq., of which: in the grain production a quantity of 1927 kg/ha (43%) respectively 7053 kg/ha CO₂ eq is fixed; in the production of stems+leaves 2212 kg/ha respectively 8095 CO₂ eq is fixed; in the production of roots 299 kg/ha carbon respectively 1094 CO₂ eq is fixed. At the level of the total area cultivated with corn grain (150 ha) the total quantity of carbon captured and fixed is 667 t, respectively 2438 t CO₂ eq. The average C/N ratio is 31.2, which indicates an average intensity of the decomposition rate of organic matter in all components of corn grain production.

Table 3. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of barley grain crop (100 ha)

Barley grain biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Grain production	5,71	571	43	0,92	46,7	2455	245 (42%)	8985	897
Roots production	6,2	620	37,4	1,22	30,6	2319	232 (40%)	8488	849
Strains productions	2,15	215	42	0,9	46,7	903	90 (16%)	3305	329
Stubble production	0,34	34	38,3	0,72	53,2	130	13 (2%)	476	48
Total	14,4	144	-	-	44,3	5807	580 (100%)	21254	2123

Barley, as a fodder crop, occupies an important place in animal feed and is therefore cultivated on

a large area within the vegetable farm. The total amount of fixed carbon is 5807 kg/ha (21254 kg/ha CO₂ eq), structured as follows: grain production with a quantity of 2455 kg/ha (8985 kg/ha CO₂ eq, 42%), root production with 2319 kg/ha (40%) fixed carbon respectively 8488 kg/ha CO₂ eq, straw production with 903 kg/ha fixed carbon (16%) respectively 3305 kg/ha CO₂ eq, stubble production with 130 kg/ha (2%) with 476 kg/ha CO₂ eq. The total amount of fixed carbon at the level of the total barley area (100 ha) is 580 t, respectively in equivalence 2123 t CO₂ eq. The calculated average C/N ratio is 44.3, indicating a low intensity decomposition rate. In the case of the root system, a ratio of 30.6 was calculated, indicating a medium intensity decomposition rate.

Alfalfa, through its morphological and physiological peculiarities (fixes large amounts of biological nitrogen symbiotically), with a highly developed root system, also fixes large amounts of carbon through photosynthesis.

Table 4. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of the alfalfa crop (79 ha)

Alfalfa biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt (%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	7,65	605	42,4	3	14,1	3244	256 (24%)	11873	937
Roots production	26,6	2101	38,5	2,12	18,2	10241	809 (76%)	37482	2961
Total	34,25	2706	-	-	16,15	13485	1065 (100%)	49355	3898

In the case of alfalfa, biomass has only 2 components, namely green mass or hay expressed in dry matter and root production. The largest amount of carbon is fixed in the root system, namely 10241 kg/ha (76% of the total amount of fixed carbon), representing, in equivalence, 37482 kg/ha CO₂ eq. In the above-ground production of dry matter, an amount of 3244 kg/ha (24% of the total fixed carbon) is fixed, the equivalence of 11873 kg/ha CO₂ eq. At the level of the 79 ha area cultivated with alfalfa, within the fodder system included in this project, a total amount of 1065 t C was fixed, in the equivalence of 3898 t CO₂ eq.

In the structure of fibrous forage crops for ruminants, mixtures of perennial grass species that form a meadow (long or short-term) have an important role in nutrition, especially through their energy value. The highly developed root system and the high production of aboveground phytomass directly influence the capacity to fix carbon, which is comparable to that of alfalfa. The data obtained within this project are synthetically presented in table 5.

Table 5 The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of perennial grasses (58 ha)

Gramineous biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt (%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	3,21	186	31,1	1,34	23,2	998	58 (10%)	3653	212
Roots production	22,8	1322	39,6	1,02	38,8	9029	524 (90%)	33046	1918
Total	26,01	1508	-	-	31	10027	582 (100%)	36699	2130

The following conclusions result from the data presented above: the largest amount of fixed carbon is achieved within the root production (in proportion to 90% of the total), respectively 9029 kg/ha, equivalent to 33046 kg/ha CO₂ eq; aboveground SU production fixes an amount of 998 kg/ha fixed carbon (3653 kg/ha CO₂ eq); at the level of the cultivated area (58ha) a total amount of fixed carbon of 582 t was achieved, equivalent to 2130 t CO₂ eq. The analysis of the C/N ratio for root production highlights the threshold of 38.8, which characterizes an average intensity of the organic matter decomposition process.

Sudan Grass occupies an important place in the structure of the feed ration of cattle due to its high palatability due to a high carbohydrate content compared to alfalfa or even corn. At the same time, due to its morphological peculiarities (3-5 mowing per growing season, a deep and well-developed root system), it is part of the category of species that can fix high amounts of carbon, as can be seen from the data presented in table 6.

Table 6. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of Sudan Grass crop (22 ha)

Sudan Grass biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt (%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	6,15	135	39,8	1,7	23,4	2445	54 (35%)	8949	197
Roots production	16	352	28,5	1,5	19	4560	101 (65%)	16690	367
Total	22	487	-	-	21,2	7005	155 (100%)	25639	564

The root system fixes most of the carbon (65% of the total amount), namely 4560 kg/ha, equivalent to 16690 kg/ha CO₂ eq. In the production of aboveground phytomass, the amount of fixed carbon determined was 2445 kg/ha (35% of the total amount of fixed carbon), equivalent to 8949 kg/ha

CO₂ eq. The total amount of fixed carbon on the cultivated area (22 ha) was 155 t, equivalent to 564 t CO₂ eq. The C/N ratio was 21.2, which indicates a medium-intensity decomposition rate of soil organic matter.

The sown meadow formed by the mixture of alfalfa (40%) and perennial grasses (60%), is considered the most intensive crop compared to other types of fodder mixtures. At the same time, as can be seen from the data presented in table 7, through the high dry matter production of the aboveground phytomass and the root system, this crop fixes significant amounts of carbon through the photosynthetic activity of the plants.

Table 7. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of alfalfa and gramineous crops (4 ha)

Mixture biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	6,89	28	39	2,16	18,1	2687	11 (32%)	9834	39
Roots production	19,8	79	29,3	1,73	16,9	5801	23 (68%)	21232	85
Total	26,79	107	-	-	17,5	8488	34 (100%)	31066	124

The root system, by transferring carbon to the underground biomass, fixes a larger amount of carbon (68% of the total amount), respectively 5801 kg/ha in the equivalence of 21232 kg/ha CO₂ eq. The production of aboveground phytomass fixes an amount of 2687 kg/ha carbon in the equivalence of 9834 kg/ha CO₂ eq. At the cultivated surface level (4 ha) the total amount of fixed carbon was 34 t, respectively 124 t CO₂ eq. The C/N ratio, on average 17.5, indicates an intense rate of decomposition of organic matter.

Autumn gorse, defined as a fodder mixture of an annual autumn legume species (autumn gorse) and an autumn cereal (wheat), has a participation ratio of 75/25. The relatively short vegetation period of this fodder mixture does not negatively influence the carbon fixation capacity. This situation is due to the biological particularities of the legume in the mixture, a component with a high capacity to fix atmospheric nitrogen. Thus, in the present case, fescue produces between 80-100 kg/ha of biological nitrogen, which positively influences the photosynthetic capacity of plants and, implicitly, the capacity to fix carbon.

Table 8. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of the autumn gorse crop (15 ha)

Autumn gorsebiomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	7,27	109	35,5	2,24	15,8	2581	38 (36%)	9446	139
Roots production	14,8	221	30,2	1,92	16,6	4470	67 (64%)	16360	245
Total	22,07	330	-	-	16,2	7051	105 (100%)	25806	384

The crop produces a quantity of 7.27 t/ha and a double quantity of roots (14.8 t/ha). These proportions are also directly correlated with the fixation of specific quantities of carbon. Thus, the analyses carried out showed that the root system fixes a quantity of carbon of 4470 kg/ha (64% of the total quantity of fixed carbon) in equivalence of 16360 kg/ha CO₂ eq. The production of aboveground phytomass fixes a quantity of 2581 kg/ha carbon, only 36% of the total, in equivalence of 9446 kg/ha CO₂ eq. The total quantity of fixed carbon in relation to the total cultivated area (15 ha) was 105 t, in equivalence of 384 t CO₂ eq. The C/N ratio, on average of 16.2, indicates an intense rate of decomposition of organic matter in the soil.

In the case of silage corn, the entire plant is used as animal feed, except for the root system. From the data obtained in the field and presented briefly in table 9, it results that this crop fixes a significant amount of carbon. Aboveground dry matter production fixes a quantity of carbon of 1683 kg/ha (56% of the total), equivalent to 6160 kg/ha CO₂ eq. Root production fixes a quantity of carbon of 1351 kg/ha (44% of the total fixed carbon), equivalent to 4945 kg/ha CO₂ eq. At the level of the area cultivated with silage corn, a total quantity of 777 t of carbon is fixed, equivalent to 2843 t CO₂ eq. The C/N ratio is, on average, 29.1, which indicates a decomposition of organic matter of medium intensity.

Table 9. The amount of C-CO₂ eq captured through photosynthesis and fixed in the biomass of silage corn crop (256 ha)

Corn silage biomass structure	Amount of biomass		Chemical analyses			Captured carbon		C-CO ₂ eq	
	t/ha	Total (t)	Ct (%)	Nt(%)	C/N	Kg/ha	Total (t)	Kg/ha	Total (t)
Biomass production	4,35	1114	38,7	1,37	28,2	1683	431 (56%)	6160	1577
Roots production	3,7	947	36,5	1,22	29,9	1351	346 (44%)	4945	1266
Total	8,05	2061	-	-	29,1	3034	777 (100%)	11105	2843

II. The amount of "net" carbon fixed and the general distribution of carbon fixed through photosynthesis, at the level of the forage system

Photosynthesis is the most efficient way to take up carbon C-CO₂ eq from the atmosphere, being characteristic of all plant species on Earth. The atmosphere has a surplus of approx. 300 Gt of carbon, of which plants, through photosynthesis, capture approx. 125 Gt (42%), and another part is taken up by the oceans. Also, plants return to the atmosphere, through respiration approx. 64 GtC/year (51%) and the soil (considered the largest natural carbon storage pool) returns, also through respiration, another 62 GtC/year (49%). In this way, photosynthesis compensates for the emissions generated by the natural agricultural ecosystem through absorption.

The agricultural ecosystem must compensate for the amount of carbon returned to the atmosphere through plant respiration, by applying special measures:

- creation of varieties with a high photosynthetic capacity, which capture the largest possible amount of carbon per unit area;

- application of bioeconomic technologies, which use energy sources with a low carbon content;

- application of conservative measures – minimization of mechanized soil work, permanent covering of soils with organic substances (vegetable residues resulting from harvesting, soil cover crops), increasing crop biodiversity (crop rotation with soil improving species aimed at increasing humus content, phytosanitary protection, improving nutritional conditions and soil structure).

Studies conducted in the USA have shown a reduction in N₂O emissions by 2 kgN/ha/year in the corn-soybean rotation system. As part of the research conducted in this project, a study was also conducted on the quantitative evaluation of the "gross" carbon returned to the atmosphere through respiration and the determination of the amount of "net" carbon fixed in the plant. Following the studies conducted, the losses of raw carbon captured and fixed through photosynthesis due to plant respiration represent 15% of the aboveground biomass, respectively 30% due to the respiration of the root system, microorganisms and the processes of decomposition and mineralization of organic matter in the soil.

Table 10. Calculation of the amount of "net" carbon following losses of "raw" carbon emitted through plant respiration

Forage system structure		Raw C captured by photosynthesis		Raw C –CO ₂ eq		Returned C returned by breathing		"Net" C fixed by photosynthesis		"Net" C –CO ₂ eq	
		Kg/ha	Total (t)	Kg/ha	Total (t)	Kg/ha	Total (t)	Kg/ha	Total (t)	Kg/ha	Total(t)
Wheat grain (335 ha)	Aboveground biomass	2684	899	9823	3291	401	134	2283	765	8355	2798
	Underground biomass	1805	605	6606	2215	543	182	1262	423	4618	1547
	Total	4489	1504	16429	5506	944	316	3545	1188	12973	4345
Corn grain (150 ha)	Aboveground biomass	4139	621	15149	2273	519	78	3620	543	13249	1987
	Underground biomass	299	45	1094	165	92	14	207	31	757	113
	Total	4438	666	16242	2438	611	92	3827	574	14006	2100
Barley grain (100 ha)	Aboveground biomass	3358	335	12290	1226	504	50	2854	285	10445	1044
	Underground biomass	2449	245	8964	897	734	76	1715	172	6276	628
	Total	5807	580	21254	2123	1238	126	4569	457	16721	1672
Corn silage (256 ha)	Aboveground biomass	1683	431	6160	1577	251	64	1432	367	5241	1342
	Underground biomass	1351	346	4945	1266	406	104	945	242	3458	885
	Total	3034	777	11105	2843	657	168	2377	609	8699	2227
Alfalfa(79 ha)	Aboveground biomass	3244	256	11873	937	487	38	2757	218	10091	797
	Underground biomass	10241	809	37482	2961	3069	242	7172	266	26246	2073
	Total	13485	1065	49355	3898	3556	280	9929	484	36337	2870

Gramineous (58 ha)	Aboveground biomass	998	58	3653	212	150	9	848	49	3104	180
	Underground biomass	9029	524	3304 6	1918	2709	157	6320	367	2313 1	1341
	Total	1002 7	582	3669 9	2130	2859	166	7168	416	2623 5	1521
Mixture (4 ha)	Aboveground biomass	2687	11	9834	38	404	2	2283	9	8356	33
	Underground biomass	5801	23	2123 2	85	1740	7	4061	16	1486 3	59
	Total	8488	34	3106 6	124	2144	9	6344	25	2321 9	92
Sudan Grass (22 ha)	Aboveground biomass	2445	54	8949	197	367	8	2078	46	7605	167
	Underground biomass	4560	101	1669 0	367	1258	28	3302	73	1208 5	266
	Total	7005	155	2563 9	564	1625	36	5380	119	1969 0	433
Autumn gorse (15 ha)	Aboveground biomass	2581	38	9446	139	387	8	2194	33	8030	120
	Underground biomass	4470	67	1636 0	245	1341	20	3129	47	1145 2	763
	Total	7051	105	2580 6	384	1728	28	5323	80	1948 2	883
Total 1019 ha	Aboveground biomass	2590	2639	9479	9659	388	395	2202	2243	8059	8212
	Underground biomass	4450	4534	1628 7	16596	1335	1360	3115	3174	1140 1	11617
	Total	7040	7173	2576 6	26255	1723	1755	5317	5417	1946 0	19829

Following the analyses carried out on the quantitative assessment of the raw carbon captured and fixed through photosynthesis, a series of values were obtained which, when systematized, processed and interpreted, generated a series of conclusions presented in the table above (Tables 1-9). Table 10 presents the total quantities of carbon (per ha and per entire cultivated area) associated with the 3 categories studied, namely "gross" C, C returned through respiration and "net" C. The analysis of these data highlights the following:

- the total amount of carbon captured and fixed at farm level is 7173 t, of which 2639 t (37%) is found in aboveground biomass, respectively 4534 t (63%) at the level of belowground biomass. The average for each cultivated ha is 7040 kg C/ha, of which 2590 kg/ha found within aboveground biomass and 4450 kg/ha at the level of belowground biomass. The total value, expressed in CO₂ eq is 26255 t CO₂ eq, with an average per ha of 9659 kg CO₂ eq at aboveground level and 16596 kg/ha CO₂ eq at belowground level

- following the respiration processes in plants and soil, the total amount of carbon returned to the atmosphere is 1755 t, of which 1360 t comes from underground biomass (77%) and 395 t (23%) from aboveground biomass. The calculation per hectare highlights a total carbon loss, through respiration, of 1723 kg/ha, of which 1335 kg/ha from belowground biomass and 388 kg/ha from aboveground biomass.

- after calculating the difference between the total amount of raw carbon and the total amount of carbon returned through respiration, the total amount of carbon fixed through photosynthesis was obtained. In this regard, the data obtained show that at the farm level, on the total area of the forage system (1019 ha), the total amount of net carbon is 5417 t (19829 t CO₂ eq), of which, in the underground biomass we find the average amount of 3174 t (11617 t CO₂ eq, 59%) and in the aboveground biomass we find the amount of 2243 t (8212 t CO₂ eq, 41%). The average amount of net carbon fixed per hectare is 5317 kg (19460 kg/ha CO₂ eq) of which 3115 kg/ha (11401 kg/ha CO₂ eq) in belowground biomass and 2202 kg/ha (8059 kg/ha CO₂ eq) in aboveground biomass.

- long-term or short-term fixed and immobilized carbon at the level of the main production (grains, phytomass, silage) and secondary production: 2.2 t/ha C (8.05 t/ha CO₂ eq) respectively a total quantity of 2243 t (8209 t CO₂ eq) in proportion to 31.3%;

- long-term or short-term fixed and immobilized carbon at the level of roots, stubble, plant residues and soil: 3.12 t/ha C (11.42 t/ha CO₂ eq) respectively a total quantity of 3174 t C (11617 t CO₂ eq) in proportion to 44.2%;

- carbon fixed and returned to the atmosphere through plant-soil respiration: 1.72 t/ha C (6.3 t/ha CO₂ eq), respectively a total quantity of 1755 t C (6423 t CO₂ eq), in proportion to 24.5%.

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Astronomy

HOW SATURN CREATED STABLE VISIBLE DENSE RINGS USING GRAVITY AND ITS MAGNETIC FIELD. A MATHEMATICAL EXAMINATION

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Abstract

We propose mechanism accounting for the genesis of Saturn's visible dense rings from the ice bodies of the protoplanetary cloud. It shows how Saturn could create dense rings using its gravitational and magnetic fields. Also we consider magnetic force leading to diamagnetic expulsion. This force is acting together with the gravitational and centrifugal forces on the ice bodies within protoplanetary cloud. The action of diamagnetic expulsion shifts the Kepler's orbits of icy bodies toward the plane of the magnetic equator, where the ice body energy is minimal. Ultimately, every ice body acquires its stable orbit in the magnetic equator, and the net force prevents radial and vertical shift of ice bodies. In our study all previous theories of the origin of Saturn's visible dense rings are not questioned, we just added the action of diamagnetic expulsion force which helps to shifts the Kepler's orbits of ice bodies toward their stable position in plane of the magnetic equator which almost coincide with geographical one.

Unified Astronomy Thesaurus concepts: Planetary ring divisions (1253); Planetary rings (1254); Saturn (1426); Solar system (1528); Astrophysical magnetism (102);

1. Questions about origin of Saturn's rings and suggestions

We consider the origin of visible dense rings only, which consist of ice bodies ranging in size from millimeter to meters [Kuiper 1949, 1-13].

We do not consider diffuse rings and dusty plasma, which have been studied with influence of gravitational force, solar radiation pressure force, Lorentz force and drag forces [14-20].

Questions about the origin, evolution, and age of Saturn's dense rings remain unanswered since Galilei first saw them in 1610. Maxwell (1859) proved that rings consist of separated parts, Kuiper (1947) predicted that visible dense rings are made up of ice, and NASA Cassini probe (2004-2017) confirmed that dense rings consist of 90%-95% water ice [2].

The well-known explanations of the emergence of Saturn's rings are based on the ideas of a gravitational defragmentation of a massive body that approached Saturn, tidal disruption of a comet, etc. followed by the collision-induced collapse of the spinning cloud [21].

What is missing in the existing scenarios is how the sombrero disk of dense rings is so perfectly made up at the equator of Saturn with extraordinary narrow flatness. The existing ideas poorly explained horizontal and vertical stability of ice bodies in the visible dense rings, and their stability

If we compare the thickness-to-length ratio of a sheet of A4 paper with that of Saturn's dense ring system, then the relative thickness of the dense rings will be thousands times smaller. It is amazing that such a thin icy disk of huge diameter hangs in outer space. The questions arise as to whether all possible Saturn – ice bodies interactions in the planetary cloud have been taken into account in the previous theories and whether a possible role of other interactions in the existence of the dense rings has not been overlooked [2, 5].

Important fact is Cassini probe measured the ratio of deuterium and hydrogen isotopes for the ice of Saturn's dense rings and found it is the same as for the Earth's ice [22]. From the infrared image taken by the Cassini spacecraft, the temperature of Saturn's visible dense rings vary from 70K to 110K, and it is below 73K over the entire area of the rings at equinox. Ice XI that is stable below ~73K can be the main polymorph modification of ice in Saturn's dense rings and it is diamagnetic (Fig. 1) [23]. Thus, it is likely that the ice bodies of Saturn's dense rings have the same behavior like Earth's ice XI [24].

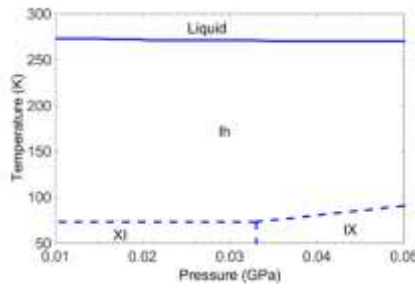


Fig. 1. Low-pressure and the low-temperature part of the phase diagram of ice XI [23]

2. Origin of visible dense rings from the ice bodies of protoplanetary cloud

Let's briefly explain our theory. We assert that the angular momentum conservation is not the only reason for the collision-induced flattening of the spinning cloud of ice bodies around Saturn. Under the additional action of Saturn's magnetic field all the Kepler's orbits of ice bodies inside the planetary nebula shifted to the plane of the magnetic equator. As a result, the cloud of ice bodies surrounding Saturn ended up by collapsing into a disk with the ice bodies orbiting in the planet's magnetic equator plane. Thus, a host of bodies formed the disk-shaped system of visible dense rings. We need to solve problem how, after the interaction of the magnetic field of Saturn with the diamagnetic ice bodies of Saturn's planetary cloud, all their orbits should come to the plane of magnetic equator and create a system of dense rings. All the ice bodies must be eventually trapped inside a three-dimensional magnetic well in the plane of Saturn's magnetic equator [24-37].

We need to demonstrate how a cloud of ice pieces can collapse into a disk of dense rings (Fig.2). To do this, we need to solve the problem of how Saturn's magnetic field all Kepler's orbits of diamagnetic ice bodies of the planetary cloud under the common action of gravitational and magnetic fields of Saturn fell onto the magnetic equator plane and created a system of dense rings.



Fig.2. Evolution of Saturn's planetary cloud into disk-shaped dense rings after the emergence of Saturn's magnetic field and its interaction with ice pieces: from (a) → to (b) → to (c)

We use the Safronov's theory of small nebula [37]. The approach to the mathematical solution of this problem is based on the fundamental theory presented in. First, we solve the problem of diamagnetic expulsion for one ice body, and then we apply it to solve the same problem for many ice bodies packed in the Saturn's rings. This allows us to avoid the tedious study of the trajectories of the ice bodies and go directly to explanation of observed phenomena in the dense rings system.

It is worthwhile to note that Saturn has a spherically symmetric gravitational field and an axisymmetric magnetic field. First, we solved problem of magnetization of spherical ice bodies in the external magnetic field, and then, by analogy, the solution was extended to a system of identical uniformly magnetized ice bodies with constant number density in an infinite disk-like structure. The equations of collisionless motion of magnetic ice bodies orbiting at a constant radius to the center in the gravitational and magnetic field of the planet are reduced to the equation for the polar angle θ_{S-p} of the orbiting ice bodies:

$$\ddot{\theta}_{S-p} + \dot{\theta}_{S-p} \cot \theta_{S-p} = \frac{GM_S}{r_{S-p}^3} \cot \theta_{S-p} + \frac{3C\mu_0^2 m_s m_p}{2\pi^2 r_{S-p}^8 M_p} \cot \theta_{S-p} \cos^2 \theta_{S-p} \quad (1)$$

where $G = 6.67430 \cdot 10^{-11} \text{ N} \cdot \text{m}^2 \cdot \text{kg}^{-2}$ is the gravitational constant, $M_S = 5.683 \cdot 10^{26}$ is the mass of Saturn, r_{S-p} is the radial distance between the centers of Saturn and the spherical piece, $m_s = 4.6 \cdot 10^{18} \text{ T} \cdot \text{m}^3$ is the magnitude of magnetic moment of Saturn [38], M_p is the particle mass, and C is the Clausius-Mossotti coefficient for magnetic spheres, which depends on the piece environment.

The only singular solution of (1) is: $\theta_{s-p} = \pi/2$. It accounts for essentially narrow planar structure of Saturn's visible dense rings and location of all ice bodies in the magnetic equator plane. The relationship for the azimuthal velocity of the piece is:

$$\dot{\phi}_{s-p} = \sqrt{GM_S/r_{s-p}^3 + 3C\mu_0^2 m_s m_p / (8\pi^2 r_{s-p}^8 M_p)} \quad (2)$$

Consequently, the diamagnetic expulsion of ice body in the cloud is weaker than that of ice piece in a disk-like structure and that of a sole ice body. Because there are no constraints imposed on the nebula radius, the environment factor can be infinitely great and the diamagnetic force vanishingly small. Thus, the magnetic force acting on the ice bodies, in the evolution of the planetary nebula to the disk-shaped system of dense rings, increases in magnitude.

Conclusions

We have started solving the problem of magnetization and, consequently, the potential energy of a spherical ice body in the magnetic field of Saturn, and we use this solution to describe the dynamics of ice body in the superposition of gravitational and magnetic fields of the planet. The solution of the equations of motion in the gravitational field only yielded the angular velocity components whose ratio, under an assumption of ice piece collisions occasionally happening, turned out to be extremely unlikely, which speak against the purely gravitational approach to Saturn's dense rings.

We demonstrated that diamagnetism of the ice bodies is responsible for the origin and stability of dense rings. Magnetic field of Saturn is non-uniform. Its lines are concentrated near the poles and rarefied in the plane of magnetic equator, which almost perfectly coincides with the geographic equator of Saturn. All diamagnetic ice bodies in non-uniform magnetic field are going to be expelled into weak-field areas, and this feature provides a minimum of the potential energy of visible diamagnetic ice bodies in Saturn's magnetic equator plane.

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Economic sciences

CORPORATE SOCIAL RESPONSIBILITY OF MANAGERS

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Abstract

The purpose of this report is to analyze the corporate social responsibility of managers at the modern stage and to search for ways of further development. The theoretical and methodological basis of the research is the relevant publications, as well as Internet Resources, which reflect the analysis and assessment of the practical experience of Georgia and the European Union countries.

The given theses discuss an importance of corporate social responsibility of innovative management. The close connection of corporate social responsibility with the concept of sustainable development is also presented. The positive aspects of corporate social responsibility of managers of the 21st century are identified; Also, as a conclusion, priority directions of corporate social responsibility of managers of innovative companies of Georgia and the European Union countries are formulated.

Keywords: Manager, Corporate, Social, Responsibility, Innovative, Sustainable, Development.

Corporate social responsibility (CSR) refers to people and organizations that behave and conduct Business in an Ethical Manner. By practicing corporate social responsibility, Managers become more aware of their impact on society and the environment, and take the necessary steps to make a positive contribution.

Corporate social responsibility is a strategy by which companies constantly compete with each other and, as a result, achieve positive results for both Business and Society. Innovative companies are constantly trying to maximize their responsibility to society at large and this trend is slowly gaining momentum in Georgia. The CSR campaign is based on the main principle - Sustainable Development. This contributes to the sustainable development not only of the company, but also of all its stakeholders.

In general, even among researchers and International Organizations, there is no clear consensus on why a CSR campaign is important, although there is a general agreement that this is a Business model that can minimize the Economic, Social, and environmental interests of an Innovative Company. The results are partly reflected in the organization's performance. Corporate social responsibility, as a mutually beneficial action for society and the company, is not a widespread practice in Georgia. CSR strategy defines a company's responsibilities and helps Management quickly determine which social problems an Innovative Organization should address and how to address them. The first thing a company does when defining a Marketing Plan is to establish Communication with the public, conduct research, meet interested parties, and then decide on the areas in which it will take responsibility.

Corporate social responsibility is a valuable tool for Effective Communication with society, ensuring stability, sustainable development and improving business reputation. The interests of society are the basis for social business investments. Consumers are paying more attention to a company's social performance, and potential donors are increasingly interested in corporate social responsibility programs when choosing a donor. Organizations that are involved in social activities are more likely to donate than donors.

As a result of the rapid expansion of the Global Market, Managers of Leading Georgian companies have increasingly begun to include social responsibility in their development strategies. In recent years, social responsibility has been developing in Georgia. It has evolved from a voluntary donation and sponsorship to a strategic, comprehensive, sustainable and beneficial intervention for all. Managers of innovative organizations are increasingly focusing on sustainable community programs and recognize an importance of these actions in building a competitive edge.

The only way to achieve a lasting project is through a genuine corporate social responsibility, not a one-time charity event. In the 21st century, consumers set high standards for business. Today, they demand more from business than just Economic Benefits. Since companies have analyzed the need for corporate social responsibility, they have been implementing different activities in different directions. This is the goodwill and ethical action of the company, through which it is possible to contribute to solving the Social, Ecological and Economic problems existing in the country. At the same time, companies care not only about satisfying the needs of their own customers, but also take into account the expectations of other people. According to the concept of social responsibility, the goal of a Manager is not only to maximize profits or shareholder returns, but also to protect the interests of other members of society, such as Talent, Consumers and Society as a whole.

Companies that have taken on social responsibility are more trusted by consumers; it can create a company's image, Employee morale increases, which in turn leads to greater productivity. Practice has shown that innovative companies that have taken on social responsibility have increased sales, achieved operational cost savings and have a greater ability to retain Human Resources. This is a way to achieve sustainability. Its basic principles, such as accountability and transparency, can ensure the long-term viability and success of any organization or system. Companies that have taken on social responsibility are less affected by scandals, rumors and other events that can damage the company's reputation.

Corporate social responsibility is based on the voluntary principle of responding to social problems in society and is not defined by applicable legislation or regulatory measures. Today, corporate social responsibility is gaining increasing importance. The surveyed Managers believe that the impact on increasing business social responsibility is real, has great importance and will grow, despite some resistance from ordinary Human Resources to the participation of an innovative company in social programs due to the demands for greater profit and revenue growth.

Significant charity work was carried out in the last century and is still carried out by Georgian businessmen in the fields of Education, Science, Culture and Sports. Therefore, innovative organizations should direct part of their resources and efforts to the benefit of local communities in which the company and its subdivisions operate. It is also worth noting that not only large organizations can assume social responsibility. If a company cannot conduct its business profitably, the issue of social responsibility acquires primarily an academic character. But be that as it may, innovative organizations need to conduct their affairs in accordance with public expectations. In other words, social responsibility for a company means more than just philanthropic activities.

The social responsibility of a company, first of all, as stated in the current theses, implies compliance with existing social, economic and environmental laws and, on this basis, the assumption of additional, voluntary obligations. And in countries where the law does not establish minimum social and environmental standards, a responsible company needs to be guided by generally recognized international norms. Corporate responsibility is an integral part of the company's core business activities, and not an additional activity for the purpose of marketing or PR communication. It is an innovative method of doing business that involves taking into account social and environmental issues, both in business strategy and in all components of the company's activities at the level of implementing policies, Management Systems and Programs.

Corporate social responsibility is closely related to the concept of sustainable development. Since sustainable development includes Economic, Social and environmental goals recognized and shared by all mankind, its concept reflects the expectations and demands of society, which responsible companies must take into account.

Therefore, corporate social responsibility is an essential concept for business, through which the Management of an innovative company contributes to sustainable development and, of course, has a positive impact on society. By implementing a successful CSR strategy, innovative companies can strengthen their reputation, establish more effective relationships with stakeholders, as well as attract and retain customers and, of course, receive Financial Benefits.

The development of a corporate social responsibility strategy by the Management of an innovative company and the planning of activities in this direction are profitable for both the business and its employees and customers.

Conclusion: *Thus, the ultimate goal of corporate social responsibility is to promote sustainable development by the company's Management and contribute to the achievement of its goals.*

Today, corporate social responsibility is a much broader concept than charity, sponsorship and philanthropy. However, they are considered as components of CSR.

For Managers of Innovative Companies in Georgia and the European Union, the priority areas of corporate social responsibility should be: Education, Employment, Business, Women's Empowerment, Environmental Protection and Support for Innovations.

QUALIFICATION ADAPTATION OF THE WORKFORCE TO THE NEEDS OF THE REGIONAL LABOR MARKET: THE CASE OF THE KARAGANDA REGION

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КВАЛИФИКАЦИОННАЯ АДАПТАЦИЯ РАБОЧЕЙ СИЛЫ К ПОТРЕБНОСТЯМ РЕГИОНАЛЬНОГО РЫНКА ТРУДА: СЛУЧАЙ КАРАГАНДИНСКОЙ ОБЛАСТИ

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Abstract

The article examines the qualification aspects of the interaction between labor market supply and demand in a regional context, using the Karaganda region as an example. Key factors influencing the labor market structure, including demographic, economic, and institutional aspects, are analyzed. Special attention is paid to the issue of qualification mismatch and methods for its elimination. The study presents data on the current state of the labor market in the region, trends in its development, and prospects for improving the workforce training system.

The paper reviews the main theoretical approaches to labor market analysis, including classical, neoclassical, and institutional theories. An analysis of existing problems related to the imbalance between labor demand and workforce qualifications is conducted, along with recommendations for improving labor market efficiency. The obtained results can be used in the development of employment strategies and educational programs aimed at adapting the workforce to changing economic conditions.

Аннотация

В статье рассматриваются квалификационные особенности взаимодействия спроса и предложения на рынке труда в региональном аспекте, на примере Карагандинской области. Анализируются ключевые факторы, влияющие на структуру рынка труда, в том числе демографические, экономические и институциональные. Особое внимание уделяется проблеме квалификационного несоответствия, а также методам его устранения. В работе представлены данные о текущем состоянии рынка труда в регионе, тенденциях его развития и перспективах совершенствования системы подготовки кадров.

Рассмотрены основные теоретические подходы к изучению рынка труда, включая классическую, неоклассическую и институциональную теории. Проведен анализ существующих проблем, связанных с дисбалансом между спросом на рабочую силу и квалификацией работников, а также даны рекомендации по повышению эффективности рынка труда. Полученные результаты могут быть использованы при разработке стратегий занятости и образовательных программ, направленных на адаптацию рабочей силы к изменяющимся экономическим условиям.

Keywords: labor market, supply and demand of labor force, qualification mismatch, demographic factors, state employment policy, professional retraining, Karaganda region.

Ключевые слова: рынок труда, спрос и предложение рабочей силы, квалификационное несоответствие, демографические факторы, государственная политика занятости, профессиональная переподготовка, Карагандинская область.

Современный рынок труда претерпевает значительные изменения под влиянием цифровизации, автоматизации и глобализации. Для успешного функционирования экономики региона важно, чтобы спрос на рабочую силу соответствовал предложению не только количественно, но и качественно. В Карагандинской области, как и во многих других промышленных регионах, наблюдается разрыв между потребностями работодателей и уровнем квалификации кадров. Это приводит к росту структурной безработицы и недозагруженности производственных мощностей.

Актуальность темы обусловлена необходимостью разработки эффективных механизмов сбалансирования спроса и предложения на рынке труда, а также выработки стратегий профессионального обучения и переквалификации кадров.

Рынок труда представляет собой сложную систему, где взаимодействуют работодатели и работники. Его функционирование объясняется различными теоретическими подходами, каждый из которых фокусируется на определенных аспектах формирования спроса и предложения, регулирования занятости и влияния внешних факторов.

Классическая теория рассматривает рынок труда как саморегулируемую систему, где равновесие достигается за счет гибкости заработных плат. Однако этот подход не учитывает институциональные и социальные барьеры, такие как государственное регулирование, профсоюзы и влияние технологий. Неоклассическая теория акцентирует внимание на значимости человеческого капитала. Образование, опыт и квалификация определяют конкурентоспособность работника. Согласно этому подходу, вложения в развитие сотрудников повышают их доход и шансы на трудоустройство. Однако доступ к образованию и возможностям профессионального роста не всегда равномерный. Теория дуального рынка труда делит рынок на первичный (стабильные, высокооплачиваемые рабочие места) и вторичный (низкооплачиваемые, с высокой текучестью кадров). В Карагандинской области наблюдается дисбаланс между квалифицированными специалистами и низкоквалифицированными работниками, что ограничивает социальную мобильность [1].

Современные подходы учитывают влияние цифровизации, автоматизации и искусственного интеллекта. Технологии сокращают спрос на рутинные профессии, но создают новые рабочие места в IT, робототехнике и анализе данных. Гибкие формы занятости, такие как фриланс и работа через цифровые платформы, становятся все более востребованными. Ни одна из теорий не дает полного объяснения всех процессов на рынке труда. Классическая и неоклассическая концепции помогают понять долгосрочные механизмы, но не учитывают влияние цифровизации. Теория дуального рынка объясняет социальные различия, но не отражает влияние новых технологий. Современные исследования позволяют анализировать влияние автоматизации, но требуют адаптации к региональным особенностям. Для изучения рынка труда Карагандинской области необходимо учитывать сочетание всех теоретических подходов, особое внимание уделяя квалификационному дисбалансу, автоматизации и адаптации рабочей силы к новым условиям экономики [2].

Современные исследования подчеркивают влияние инноваций и технологий на рынок труда. Так, Ж. Владимиров в работе «Mediating Role of Innovations as a Factor of Firm's Competitiveness» (2021) отмечает, что инновации не только повышают конкурентоспособность предприятий, но и требуют от работников новых компетенций, таких как цифровые навыки и адаптивность. Этот подход применим к Карагандинской области, где промышленные отрасли всё больше зависят от автоматизации и цифровизации, что усиливает потребность в квалифицированных кадрах.

Факторы, влияющие на рынок труда Карагандинской области. Для анализа особенностей спроса и предложения рабочей силы в Карагандинской области важно учитывать ряд ключевых факторов, основанных на конкретных статистических данных и экономических показателях.

Экономическая структура региона играет определяющую роль в формировании занятости. Карагандинская область является одним из крупнейших промышленных центров Казахстана. По данным 2021 года, население региона составляет около 1,3 миллиона человек, а его вклад в валовой региональный продукт достигает 5,8% от национального уровня. В

промышленности доминируют горнодобывающая отрасль, металлургия, энергетика и машиностроение. Горнодобывающая промышленность обеспечивает 35–40% всего промышленного производства, в ней занято около 120–130 тысяч работников. Металлургия занимает 25%, что соответствует 80–90 тысячам рабочих мест. В энергетике задействовано около 70–80 тысяч человек, а в машиностроении – 40–50 тысяч. Несмотря на высокую концентрацию промышленных предприятий, в ряде отраслей наблюдается дефицит квалифицированных кадров, особенно в технических специальностях [3].

Демографическая ситуация оказывает значительное влияние на рынок труда. В регионе насчитывается около 650 тысяч человек трудоспособного возраста, что составляет половину всего населения. Однако рост доли лиц старше 60 лет сокращает количество молодых специалистов, доступных для работы. Отток молодых специалистов в столичные города Казахстана, такие как Нур-Султан и Алматы, усиливает проблему кадрового дефицита. До 10–12% выпускников технических вузов региона предпочитают миграцию в поисках лучших условий работы. В то же время наблюдается увеличение числа приезжих работников, но в основном на неквалифицированные позиции, что не решает проблему нехватки квалифицированного персонала.

Квалификационные характеристики рабочей силы выявляют дисбаланс между структурой подготовки кадров и потребностями экономики. В Карагандинской области ощущается дефицит инженерных и технических специалистов, особенно в сфере автоматизации, машиностроения и ИТ. По оценкам работодателей, нехватка таких кадров составляет 20–25%. Одновременно с этим наблюдается переизбыток специалистов в сферах экономики, юриспруденции и управления, что создает высокую конкуренцию и снижает уровень заработных плат. Только около 30% работников имеют доступ к программам повышения квалификации, что ограничивает их возможности адаптации к изменениям на рынке труда [4].

Инфраструктурные и институциональные условия также оказывают влияние на рынок труда. В регионе действует 6 вузов и 10 колледжей, однако лишь 40% из них сотрудничают с предприятиями для организации практических стажировок, что снижает качество подготовки выпускников. Региональные программы занятости, такие как субсидирование рабочих мест и налоговые льготы для предприятий, инвестирующих в подготовку кадров, охватывают примерно половину организаций области. В условиях ограниченного финансирования развитие дуального образования и системы наставничества остается на низком уровне – только 15–20% студентов получают возможность обучения в рамках таких программ. Анализ факторов, влияющих на рынок труда в Карагандинской области, показывает, что его динамика определяется экономическими, демографическими, квалификационными и институциональными условиями. Основные отрасли экономики требуют наличия высококвалифицированных специалистов, однако демографические вызовы и миграционные процессы усугубляют проблему кадрового дефицита. Кроме того, несоответствие структуры подготовки кадров реальным потребностям бизнеса усиливает дисбаланс между спросом и предложением рабочей силы. Ограниченность программ профессиональной переподготовки и слабая интеграция образовательных учреждений с бизнесом также снижают эффективность рынка труда. Эти данные являются основой для разработки стратегий по улучшению системы подготовки кадров, адаптации рабочей силы к изменяющимся экономическим условиям и повышению эффективности рынка труда в регионе [5].

Инновационная активность предприятий также влияет на спрос на рабочую силу. Согласно Ж. Владимирову и А. Уильямсу («Hotel innovations and performance: the mediating role of staff related innovations», 2018), инвестиции в обучение персонала и внедрение инноваций повышают производительность труда. В Карагандинской области это особенно актуально для горнодобывающей и металлургической отраслей, где автоматизация требует от работников новых технических компетенций.

Проблема квалификационного несоответствия на рынке труда Карагандинской области. Одной из наиболее острых проблем рынка труда Карагандинской области является несоответствие квалификации выпускников образовательных учреждений требованиям работодателей. Это создает значительный дисбаланс между спросом на рабочую силу и ее предложением, что приводит к структурной безработице и недозанятости.

Причины квалификационного несоответствия. Первой причиной является **отставание учебных программ от современных потребностей рынка труда**. Вузы и колледжи региона продолжают готовить специалистов по устаревшим учебным планам, которые не учитывают

динамичные изменения в экономике и развитие цифровых технологий. По данным Министерства образования Казахстана, лишь 30–35% программ в технических вузах соответствуют актуальным требованиям работодателей. Например, в Карагандинской области недостаточно учебных курсов по автоматизированному производству, программированию и цифровому моделированию, несмотря на высокий спрос на такие компетенции в промышленности.

Вторая причина – **недостаточное сотрудничество между учебными заведениями и предприятиями**. В регионе действует 6 университетов и 10 колледжей, однако только около 40% из них имеют партнерские программы с промышленными предприятиями. Это приводит к тому, что выпускники получают недостаточно практических навыков, что снижает их конкурентоспособность на рынке труда. Например, по данным опросов работодателей, проведенных в 2022 году, 65% выпускников технических вузов испытывают сложности с трудоустройством из-за нехватки практического опыта.

Третья причина – **низкая популярность технических специальностей среди молодежи**. В последние годы наблюдается тенденция к росту числа студентов, обучающихся по направлениям «экономика», «юриспруденция» и «государственное управление». В то же время интерес к инженерным, строительным и IT-специальностям остается недостаточным. По данным Министерства труда, в 2021 году только 18% абитуриентов выбрали технические специальности, в то время как в экономике и юриспруденции этот показатель составил более 35%. Такая диспропорция создает избыток специалистов в гуманитарных сферах и нехватку кадров в стратегически важных отраслях промышленности.

Четвертая причина – **ограниченный доступ к программам профессиональной переподготовки**. В условиях быстрого развития технологий многим работникам необходимо обновлять свои знания и осваивать новые компетенции. Однако в Карагандинской области только 30% трудоспособного населения имеют доступ к программам переквалификации. Для сравнения, в странах Европейского союза этот показатель достигает 50–60%. Ограниченные возможности профессионального обучения затрудняют адаптацию работников к изменениям на рынке труда и повышают риск их увольнения [6].

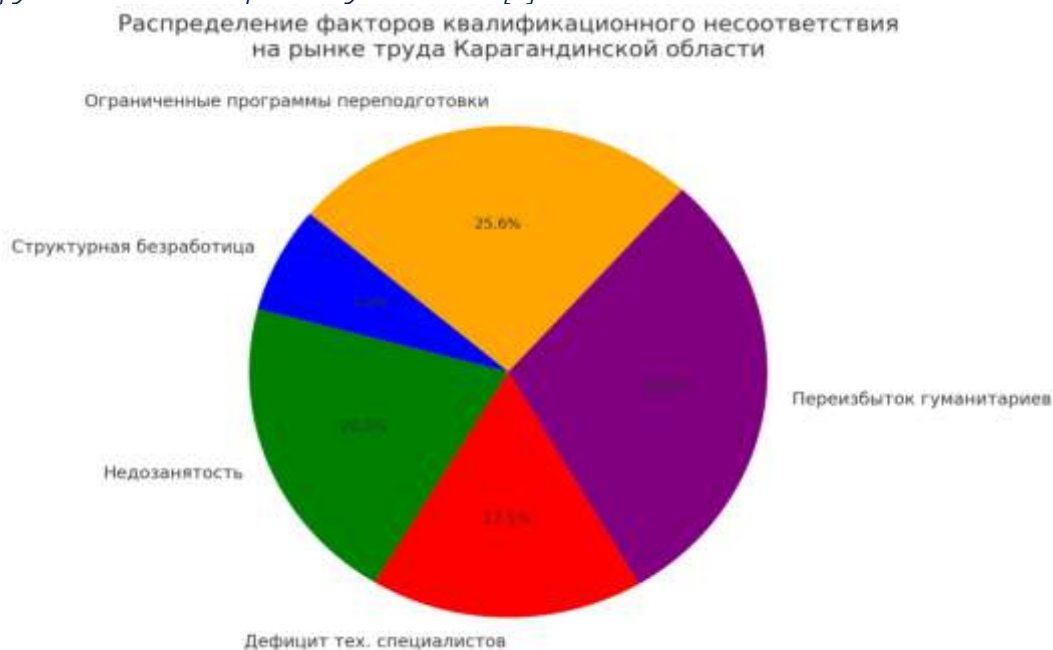


Рисунок 1 – Распределение факторов квалификационного несоответствия на рынке труда Карагандинской области

Последствия квалификационного несоответствия. Главным последствием данной проблемы является **структурная безработица**. В Карагандинской области по данным 2022 года уровень безработицы составляет около 4,8%, однако среди молодежи (в возрасте 18–29 лет) этот показатель достигает 8,2%. При этом в ряде отраслей наблюдается дефицит специалистов. Например, в горнодобывающей промышленности и металлургии не хватает порядка 15–20% квалифицированных работников, в то время как на рынке труда присутствует избыток экономистов, юристов и менеджеров. Это означает, что рабочие места есть, но работодатели не могут найти специалистов с необходимыми навыками. Другим последствием

является **недозанятость**, когда работники вынуждены трудоустраиваться не по своей специальности или занимать менее квалифицированные должности. Например, в 2021 году 24% выпускников вузов Карагандинской области были вынуждены искать работу в сферах, не связанных с их образованием. Особенно это касается гуманитарных специальностей, выпускники которых часто устраиваются в торговлю, сферу обслуживания или офисную администрацию, несмотря на наличие высшего образования.

Недозанятость также приводит к **недостаточному использованию человеческого капитала**. Выпускники вузов, работающие не по специальности, сталкиваются с более низкими зарплатами и ограниченными возможностями карьерного роста. По статистике, средний уровень зарплаты в технических и инженерных профессиях в регионе составляет около 350–400 тысяч тенге, тогда как выпускники гуманитарных специальностей, работающие не по профессии, зарабатывают в среднем 200–250 тысяч тенге. Это снижает мотивацию молодежи к получению образования и повышению квалификации. Проблема квалификационного несоответствия в Карагандинской области требует комплексного решения, включающего модернизацию учебных программ, расширение партнерских связей между образовательными учреждениями и предприятиями, популяризацию технических профессий среди молодежи и развитие программ переквалификации. Без устранения этого дисбаланса рынок труда региона продолжит сталкиваться с нехваткой квалифицированных кадров и ростом структурной безработицы[7].

Способы устранения дисбаланса на рынке труда. Для обеспечения эффективного взаимодействия спроса и предложения на рынке труда необходимо внедрять комплексные меры, направленные на устранение квалификационного несоответствия, повышение конкурентоспособности работников и адаптацию системы подготовки кадров к реальным потребностям экономики. Учитывая особенности рынка труда Карагандинской области, ключевыми направлениями решения данной проблемы являются модернизация системы образования, развитие профессионального обучения, государственное регулирование и популяризация рабочих профессий среди молодежи.

Модернизация системы образования играет ключевую роль в устранении дисбаланса между спросом и предложением рабочей силы. Важно обновить учебные программы с учетом современных технологических изменений, чтобы подготовка специалистов соответствовала требованиям работодателей. Например, в инженерных и технических вузах необходимо внедрение дисциплин, связанных с автоматизацией, цифровым моделированием, искусственным интеллектом и программированием. Это позволит выпускникам обладать востребованными компетенциями и сократит разрыв между теоретическим образованием и реальными производственными потребностями. Развитие дуального образования становится одной из наиболее эффективных моделей подготовки кадров, при которой студенты совмещают теоретическое обучение с практикой на предприятиях. Такая система уже успешно функционирует в Германии и Австрии, где более 50% учащихся проходят обучение в формате дуального образования. В Карагандинской области данное направление также может стать ключевым инструментом устранения квалификационного разрыва, если вузы и колледжи налаживают сотрудничество с промышленными предприятиями региона. Это позволит студентам получать практические навыки и быстрее адаптироваться к требованиям работодателей [8].

Гибкие формы занятости и переподготовка кадров являются важными инструментами устранения квалификационного разрыва. Ж. Владимиров и И. Янчовска в статье «Flexible working and IT employees' job satisfaction before and during COVID-19» (2023) подчеркивают, что внедрение гибких рабочих моделей повышает удовлетворенность сотрудников и их готовность осваивать новые навыки. В контексте Карагандинской области это может быть использовано для привлечения ИТ-специалистов и развития программ дистанционного обучения.

Введение курсов цифровых навыков и инженерных дисциплин должно стать приоритетом образовательных реформ. В условиях цифровой трансформации экономики все больше профессий требуют знаний в области ИТ, аналитики данных и автоматизированного управления процессами. Согласно исследованиям, к 2030 году около 60% рабочих мест потребуют владения цифровыми технологиями. Поэтому интеграция таких курсов в программы высшего и среднего образования поможет будущим специалистам быть конкурентоспособными на рынке труда. Стимулирование профессионального обучения и переквалификации также является важным шагом к устранению дисбаланса на рынке труда. Развитие центров переподготовки кадров позволит людям, которые оказались вне востребованных профессий, освоить новые

компетенции и найти работу в перспективных отраслях. В странах Европейского союза до 50% работников хотя бы раз в жизни проходят переквалификацию, что помогает им адаптироваться к изменениям на рынке труда. В Карагандинской области необходимо увеличить количество таких центров, особенно в малых городах и сельских районах, где доступ к обучению ограничен.

Создание доступных онлайн-курсов и программ дистанционного обучения поможет расширить возможности профессионального роста для работников, которые не могут проходить очное обучение. Онлайн-платформы, такие как Coursera, Udacity и Khan Academy, уже показали свою эффективность в развитии цифровых и инженерных компетенций. В Карагандинской области можно внедрить государственные и частные образовательные платформы, которые позволят работникам и студентам получать дополнительные знания без необходимости менять место жительства или прерывать работу. Финансовая поддержка работников, желающих освоить новую профессию, может стать действенным инструментом стимулирования профессионального развития. Государственные гранты, образовательные кредиты и программы субсидирования обучения помогут снизить финансовые барьеры и мотивируют работников к освоению востребованных специальностей. Например, в Сингапуре существует программа SkillsFuture, в рамках которой каждому гражданину предоставляется определенная сумма на обучение и развитие профессиональных навыков. Введение подобных механизмов в Казахстане поможет повысить мобильность рабочей силы и снизить уровень квалификационного несоответствия.

Государственная поддержка и регулирование также играют важную роль в балансировке спроса и предложения на рынке труда. Одним из эффективных инструментов являются программы субсидирования рабочих мест в стратегически важных отраслях. Например, в сфере цифровой экономики, инженерии и научных исследований государство может субсидировать зарплаты молодых специалистов, что повысит их мотивацию работать в данных отраслях. Подобная практика успешно применяется в ряде стран, включая Южную Корею и Канаду. Введение налоговых льгот для предприятий, инвестирующих в подготовку кадров, поможет стимулировать бизнес к активному участию в обучении работников. Компании, которые проводят курсы переподготовки или создают корпоративные университеты, могут получать налоговые вычеты, что снижает их затраты на обучение персонала и способствует повышению квалификации работников [9].

Развитие механизмов прогнозирования спроса на рабочую силу поможет системе образования более точно ориентироваться на потребности рынка. Использование цифровых технологий для анализа экономических тенденций и перспективных профессий позволит образовательным учреждениям адаптировать программы к требованиям экономики. В Казахстане можно создать платформу, на которой работодатели, образовательные учреждения и государственные структуры смогут обмениваться данными о текущих и будущих потребностях в кадрах. Популяризация рабочих профессий среди молодежи является важным направлением долгосрочной стратегии по устранению дисбаланса на рынке труда. В последние годы наблюдается снижение интереса молодежи к техническим и инженерным специальностям, что приводит к дефициту кадров в этих сферах. Одна из ключевых задач – проведение профориентационной работы в школах и колледжах, чтобы учащиеся могли заранее ознакомиться с возможностями профессионального роста в технических и научных областях.

Программы стажировок и наставничества помогут молодым специалистам быстрее адаптироваться к требованиям работодателей и получить необходимые практические навыки. Опыт развитых стран показывает, что участие в стажировках значительно повышает шансы выпускников на успешное трудоустройство. В Карагандинской области можно внедрить систему обязательных стажировок для студентов технических вузов и колледжей, что сократит разрыв между образованием и реальными потребностями бизнеса. Повышение престижности технических и инженерных профессий должно стать приоритетной задачей образовательной и кадровой политики. Для этого можно проводить информационные кампании, демонстрирующие перспективы карьерного роста и уровень доходов в данных профессиях. Например, в Германии активно рекламируются профессии в сфере машиностроения и информационных технологий, что способствует привлечению молодежи в эти отрасли. Решение проблемы квалификационного несоответствия требует комплексного подхода, включающего реформирование системы образования, поддержку профессионального обучения, активное участие государства и бизнеса, а также изменение восприятия рабочих

профессий в обществе. Только скоординированные действия всех заинтересованных сторон позволят создать эффективный и сбалансированный рынок труда в Карагандинской области, отвечающий вызовам современной экономики [10].

Рынок труда Карагандинской области сталкивается с серьезными вызовами, связанными с дисбалансом между спросом и предложением рабочей силы. Высокотехнологичные отрасли требуют специалистов с новыми навыками, однако система подготовки кадров не всегда успевает адаптироваться к изменениям. В результате наблюдается нехватка инженерных и технических специалистов при одновременном переизбытке работников в гуманитарных сферах, что ведет к росту структурной безработицы. Недостаточная адаптация образовательных программ и слабая связь учебных заведений с предприятиями усугубляют ситуацию. Молодежь реже выбирает технические профессии, а программы переподготовки не охватывают достаточное количество работников. Кроме того, демографические процессы, включая старение населения и миграционные потоки, оказывают влияние на рынок труда, создавая дополнительные сложности для занятости.

Для устранения квалификационного несоответствия необходим комплексный подход. Обновление образовательных программ, развитие дуального обучения и расширение доступности профессиональной переподготовки позволят улучшить соответствие подготовки кадров потребностям экономики. Государственная поддержка в виде субсидий и налоговых льгот для работодателей, инвестирующих в подготовку кадров, также может способствовать снижению квалификационного разрыва. Популяризация рабочих профессий среди молодежи через профориентацию, стажировки и наставничество станет важным шагом в решении проблемы нехватки технических специалистов. Только комплексные меры, включающие модернизацию образования, развитие программ переподготовки и активное участие государства и бизнеса, позволят сбалансировать рынок труда и создать условия для устойчивого экономического роста региона.

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THE IMPORTANCE OF ETHICAL PRACTICES AND THEIR APPLICABILITY IN THE PUBLIC AND THE PRIVATE SECTOR IN THE KORCA REGION

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Abstract

Ethics and ethical behavior are issues that are widely faced by the business world today. People are becoming increasingly interested in what is actually happening in organizations in both the public and private sectors in the name of competitiveness, growth, and profitability. An increasing number of organizations are continuously monitoring and evaluating unethical practices in business organizations around the world. The purpose of this paper is to examine the importance of ethical practices, their applicability, and the commitment of both sectors to create a more ethical business environment.

Keywords: ethic, management, business, public administration

Introduction

Ethics is a very important element in creating a good and consolidated image of the public sector and in organizing and managing the private sector well. What is noticeable is that theoretically, both in the public and private sectors, there is a broad understanding of what ethics is and the totality of the norms that shape it in particular. The problem arises in the practical aspect, where especially employees and self-employed people in the private sector show a high degree of indifference to the importance of implementing these norms in practice.

If we were to ask businessmen about the importance of a sense of responsibility, and how they would classify responsibility in relation to other qualities required at work, it turns out that "responsibility" is an almost unknown concept, especially among young businessmen. As a result of the growing social gap in the sense of personal and professional responsibility, it is not surprising that there are so many scandals in various corporations. We witness the unscrupulous violation of ethical relationships; we see how some top executives give themselves huge bonuses while their companies are reeling in a whirlwind of financial losses, while others fall prey to moral failures that, due to the scandalous message they send, are worthy of newspaper headlines. Business entrepreneurs driven by a thirst for profit often break ethical norms or even break the law. This happens in several ways.

One of the most common ways is not reporting all profits in order to avoid paying taxes. Also, we have many unregistered businesses. Another problem with businesses is the lack of contracts between employers and employees, so employers do not pay insurance for them. Another factor that affects unethical behavior is the poor knowledge of entrepreneurs about business. Lacking knowledge, entrepreneurs do not succeed in their business, so they try to achieve this success by violating ethical norms. But also the lack of experience in business development has its impact that leads entrepreneurs to violate ethical norms.

When we talk about public administration, of course we have in mind the fact that it constitutes an important sector for every society. Its efficiency and accountability help improve the state and functionality of social life. Everyone aims for an uncorrupted, professional and efficient public administration. Success in the field of public administration reforms largely depends on public servants and their willingness to make fundamental changes in the way they work. In this regard, the state must strengthen and modernize the public service, implement an employment system that will more fully reflect the merits in the service.

It is known that dissatisfied civil servants strengthen the negative image that the public has of the administration and undermine the government's efforts to build a positive image of the state and the administration as professional, objective and service-oriented.

Continuing to talk about the administration, we cannot deny the fact that ethical norms are more respected, since their very purpose is to serve the community and every action or procedure is provided

for by law, but still much remains to be done. We are all aware and cannot deny the fact that today there is a politicized administration, where political views are the best shield against measures that can be taken against non-compliance with the code of ethics.

Literature Review

1. The conception of ethics in business

In today's global and highly competitive environment in which businesses operate, ethics are considered a cornerstone for sustainable growth and long-term success.

The word 'ethics' comes from the greek word ethos, which means "character, custom, or a set of widely accepted moral behaviors". According to Solomon (1984), the etymology of ethics suggests that its fundamental concerns are: (1) individual character, including what it means to be "a good person" and (2) the social rules that govern and constrain our behavior, especially the ultimate rules regarding right and wrong, which we call morality.

Ethics in a general concept is the science that deals with the study of what is good or bad, right or wrong, lawful or unlawful. If we specify it in the field of business, ethics will be referred to as the science that studies good and evil, right and wrong, legal and illegal in business (G.Steiner&J.Steiner,2006). Ethics is the concept of morality; one's ability to choose between right and wrong, good and evil, acceptable and unacceptable (Desjardins, 2009; Valasquez, 2009).

The concept of 'business ethics' has come to mean different things to different people. Velasquez (2009) identified business ethics as a specialized study of moral right and wrong; while Garrett (1970) defined business ethics as "the relationship of business goals and techniques to specific human goals. It studies the impacts of actions on the good of the individual, the firm, the business community, and society as a whole. According to Weihrich and Koontz (1994), business ethics deals with truth and justice and has a number of aspects such as "social expectations, fair competition, advertising, public relations, social responsibilities, consumer autonomy, and corporate behavior in the country of origin, as well as abroad.

Ethics is about the standards of right and wrong that influence behavior. These standards may vary from one country to another and from one culture to another. Ethical behavior is that behavior, which is conceived as right or wrong based on these standards (Kinicki&Williams, 2011; Daft, Kendrick, Vershinina, 2010).

However, it is not so easy to act ethically. Unethical behavior or ethical mistakes today do not make a big impression when faced with it. This is because such problems have become very frequent and the media every day reports activities, unethical behavior of the government, businesses, state or private institutions in the field of sports, medicine, science, etc.

Business operates in an environment where the interests of many actors, such as investors, customers, employees, creditors, or competitors, are intertwined. These groups have their own range of interests, which in some cases are in conflict not only with each other, but also with the business. The proper implementation of business ethics in organizations can ensure the maximization of legitimate profits and effectively protect the interests of all stakeholders of business organizations, including the corporate social responsibility of business organizations, about which much has been said and written by academic researchers (Sealy, 1987, 2001; Petrini and Pozzebon, 2009; Blumberg, 1970; Machan 2009). While we acknowledge that it is not easy to influence individual behavior, there are still a number of strategies to create an ethical climate, including the importance of a code of ethics. A code of ethics is a document prepared in order for members of the organization to be guided by its principles when faced with an ethical dilemma (Sh.Llaci, 2017). It is very important that the code of ethics is communicated, monitored and implemented in business organizations (Hian and Boo, 2004). It is essential that management shows a commitment to the code of ethics and materializes it. The implementation of the code of ethics imposes the right perception on the part of employees on the role of ethics and social responsibility in achieving the long-term effectiveness of the organization (Vitell et al., 2003).

In general, the code of ethics is an issue forgotten by Albanian business organizations. This, among other things, is also related to the stage of development of Albanian business, where managers are more oriented towards the problems of consolidation and business growth and with it also profit and neglect such important issues (Sh.Llaci, 2017).

Ethics are closely related to the values and beliefs of society (S.Stillo, 2016). In the time we live in noticing the changes in the mentality of business people in Albania on ethics, we can say that businesses in our country have serious problems with it. But efforts for change and improvement are increasing, and these efforts are being made by the most educated part of society, which claims to be the most predisposed to do so.

2. Public administration and ethics

Public administration is the production of goods and services intended to serve the needs of citizens and consumers (Dimock, Fox, 1983). In common usage, public administration is a general term for all those activities involved in the definition and implementation of public policies (Graham Jr., Hays, 1986).

Public administration theory is a domain where the meaning and purpose of government, bureaucracy, budget, management and public affairs are discussed. Traditionally, public administration has been considered the implementing arm of government. It is supposed to include all those activities for the implementation of the policies of elected officials and some activities related to the development of these policies. Public administration is everything that comes after the last promise of the electoral campaign and the last toast of election night (Starling, 1997).

In recent years, public administration theory has been associated with a strong orientation towards critical theory and postmodern philosophical notions of government, governance and power, but many public administration scholars support a classical definition of the term, giving importance to constitutionalism, service, bureaucratic forms of organization and hierarchical government. Public administration also focuses on public sector values such as democracy, accountability, equality and honesty (S.Stillo, 2011).

So, in summary, it can be said that work in the public service is guided by democratic values. In carrying out the functions of a public administrator, not only efficiency and effectiveness are important, but above all accountability to all actors who determine the public interest: elected leaders, deputies, various representative groups and citizens as a whole. Bertrand and Lang also claim that public administration differs from other forms of government according to its competence and the fact that its ultimate goal is the general interest

Therefore, public administration consists of civic service, public finance, security, jurisprudence, local government and many other elements. Shafritz and Russell define public administration from four different perspectives: political, legal, managerial and professional. In the political aspect, public administration means what governments do directly or indirectly in the public interest through the policy-making cycle. In the legal aspect, public administration is defined as rules and laws in action, while from the managerial one, as the executive branch of government that requires managerial specialization based on natural talent and continuous effort. From a professional perspective, public administration is taken as a category of profession that requires good writing skills, a high dose of idealism and formal academic training.

Moral attitudes are an integral part of the organization, while high standards protect against demoniacalism". (Vildavski). According to David H. Rosnebloom and Robert S. Kravchuk, public administrators must behave with full responsibility because their work has many aspects that can lead to misunderstanding of the public interest, corruption and subversion.

In addition to the key features of personal ethics such as trustworthiness, respect, responsibility, care and honesty, impartiality, civic virtue, there are also elements from the so-called "Colero list" and "Nolan list" in which the criteria for ethical behavior of administrators or politicians with public duties are noted. Among the values that take place in the Colero list are concern for the well-being of others, respect for the autonomy of others, trustworthiness and honesty, the desire to become part of the law, primary justice to be impartial, refusal to take unfair revenge and prevention of a negative situation. In the Nolan list, which is more It is about executive decision-making with an impact on a larger layer, the following values are mentioned: not being selfish, aiming for the public interest, acting with integrity and without being influenced by others in decision-making, being objective and without conflicts of interest, being responsible, being transparent and creating the image of a trustworthy leader.

Public administration scholars have devoted efforts to examining administrative ethics. Unethical behaviors have generally been examined as informal behavior, for example, unethical is defined as the lack of desire to take responsibility, the inability to understand people, the failure to use institutional resources effectively, etc. None of these problems and behaviors in the abstract can be considered a violation of the law. Corruption and illegal actions are another part of unethical behavior (S.Stillo, 2011).

However, issues related to ethics are more interesting than non-legal ones and we can say that ethical issues contain some characteristics that make their study more difficult, because there is no consensus regarding the division of which actions can be considered ethical and which unethical and also, since ethics is situational, then what can be ethical would depend from situation to situation and from organization to organization.

Methodology used

To carry out our study and to investigate how the situation of theoretical conception and practical application of ethics is presented, we focused on the most successful businesses that develop their

activity in the Korca Region, as well as in the public sector. However, our study was designed in a qualitative way by focusing on the opinions, stories and experiences of employees of these sectors, using semi-structured interviews to collect data, as well as a questionnaire. A descriptive and analytical methodology was used to carry out the study. Data processing was done through the SPSS program.

The results of study

Our first interest in the study was whether organizations in both sectors had a code of ethics and the result was positive, as 96% of public sector organizations and 82% of private sector businesses have one. Administrations at the moment of starting a work relationship are more meticulous in presenting the code of ethics to their employees, while in the private sector, no importance is given to presenting this Code to new employees. Private sector employees are mostly introduced to the code of ethics through various trainings and not by the employer as is the case in public administration.

The administration introduces its new employee to the code of ethics from the beginning of the employment contract, up to the first 3 months of the employee's employment, while in private businesses, this action is neglected. Among the core values of the code of ethics, honesty and responsibility are most valued by employees of both sectors, but the implementation of these values does not always occur. (Fig. 1)

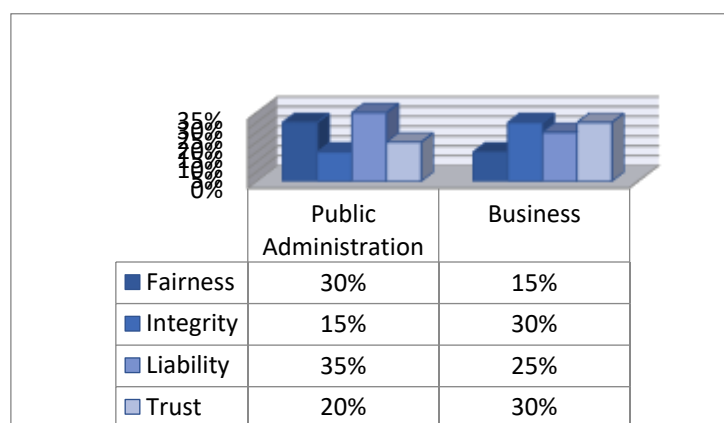


Fig. 1. Values included in the code of ethics that must be respected during work activities

In the private sector, employees do not have a strong tendency towards ethical behavior in their work relationships, while in the public sector we have an opposite presentation of this aspect. So, public sector employees during the work relationship are more inclined to be ethical. This is because business has as its primary goal its interest, profit and tries at all costs to achieve this. While the public administration employee has a higher social responsibility and takes care to improve his service by adhering to the laws and norms of the code of ethics.

If public employees aim to improve their service, private sector employees aim to increase their income, this also through ethical behavior if necessary. (Fig.2)

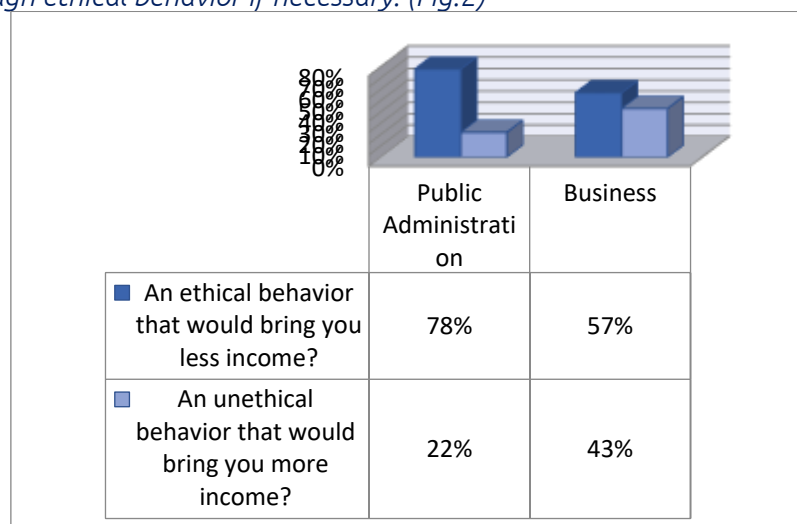


Fig.2. Orientation of employees to increase personal income

It is the Private Sector that, although rarely, encounters unethical behavior among employees than the public administration. This is certainly a consequence of the lack of knowledge of the code of ethics by employees. Among the most evident forms of unethical behavior, in the public administration we

mention corruption, which occupies a very high percentage. Corruption remains present in the private sector as well, but in this sector a part of the unethical behavior consists of sexual harassment, which, although in a small percentage, remains worrying. (Fig.3)

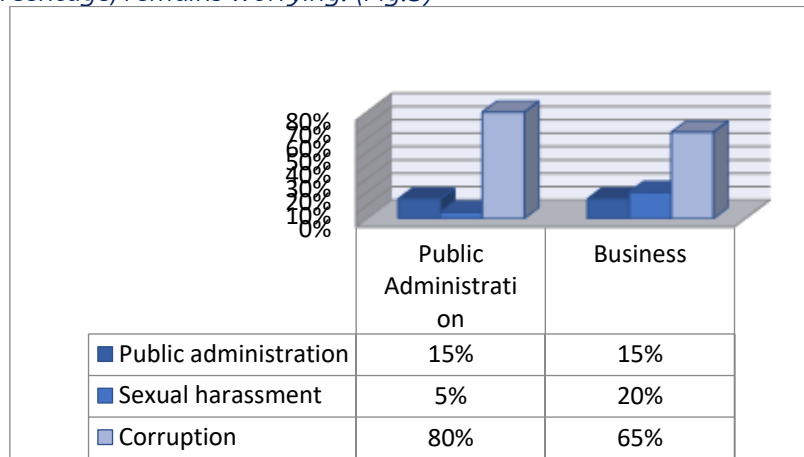


Fig.3. Unethical behaviors identified in the workplace

Regarding the reactions to the non-respect of Ethical norms, it is the public administration that criticizes this action the most, while the private sector usually remains silent when faced with such a fact. However, such unethical behaviors are still not denounced when they are observed, even though their consequences are known by everyone. The value systems that most influence being ethical remain the family and the personal codes of ethics of employees, and this applies to both sectors. The work of learning morality rightly rests on the shoulders of parents and the social environment. At the moment when the codes of ethics of the profession come into play, it is too late to change the moral predispositions of an adult. (Fig.4)

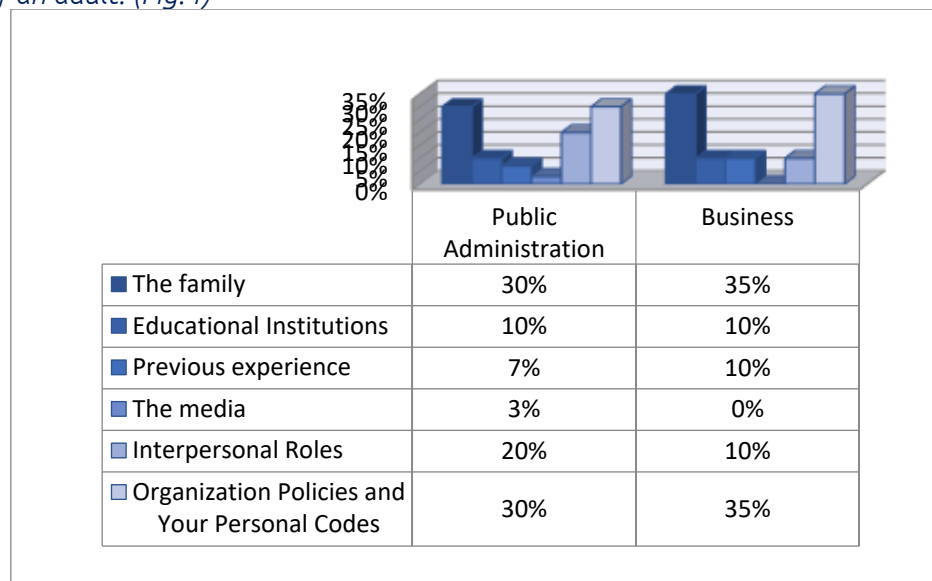


Fig.4. Value systems that most influence being ethical

But when it comes to the measures that should be taken by the relevant authorities against the non-implementation of the code of ethics, in the private sector, the most efficient is the objective respect of the penalties. Even in the public administration this measure has its importance, but a special weight to be assessed is also personal awareness. This is an important point which shows the high social responsibility that exists in this sector. (Fig.5)

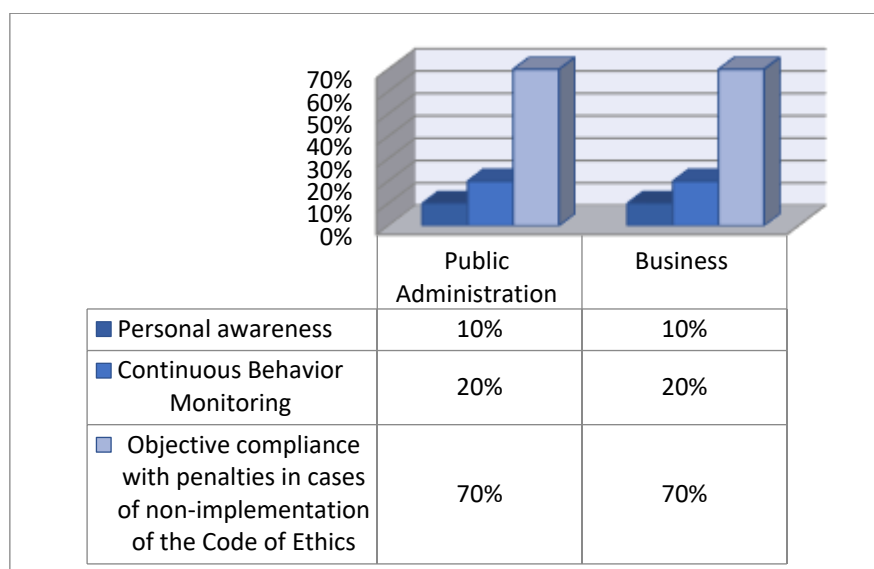


Fig.5. The most effective measures for wider compliance with the code of ethics

Conclusions and recommendations

In order for the positive effects of the implementation of ethical norms to be felt in both the public and private sectors, the relevant state and non-state authorities must exercise their control up to the application of legal sanctions in case of non-compliance. Cooperation between the two sectors is important. Entrepreneurs are the ones who must be transparent in presenting their data and administrations must be correct in implementing laws and penalties in cases of non-compliance with laws. The meritocratic employment system is another aspect that needs to be improved in both the private and public sectors. The recruitment process is the one during which the persons responsible for carrying it out must choose based on merit and professional skills. Let us hope that this society has the capacity to build moral individuals who, even in the organizational environment, act according to the most sublime values, who work, as Weber says, without soul or prejudice.

But what we need to understand and what remains most important is that everything must start with us, with personal awareness.

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REGIONAL ASPECTS OF THE DEVELOPMENT OF THE ALTERNATIVE ENERGY SECTOR IN AZERBAIJAN (IN THE LIBERATED TERRITORIES)

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Abstract

This study examines the importance of regional aspects in the development of Azerbaijan's alternative energy sector, particularly in the context of the liberated territories. The Karabakh and East Zangezur economic regions, along with their rich energy potential, have a strategic position. The declaration of the territories as green energy zones has made the development of renewable energy sources – solar, wind, hydro and bioenergy – a priority in these regions. The study analyzes the region's climate and relief features, solar radiation, wind flows and water resources. In addition, it assesses relevant technological and investment opportunities, public-private partnership models and the role of international financial institutions. The results obtained show that the development of alternative energy infrastructure promotes not only energy security, but also socio-economic revival and environmental protection. The projects contribute to the creation of new jobs, the return of the population and the transition of the region to a green economy model. The study also highlights the role of the liberated territories in strengthening Azerbaijan's energy security and expanding its export potential. In this regard, it is considered necessary to coordinate the existing policy with regional development and sustainable energy strategies. At the same time, the implementation of alternative energy projects in the liberated territories is also of great importance in terms of restoring regional balance and reducing energy inequality within the country. These territories have the potential to form as new centers on the overall energy map of Azerbaijan. Preliminary calculations on wind and solar energy show that it is possible to produce thousands of megawatts of electricity in Karabakh and East Zangezur. In addition to meeting the growing energy demand, these resources also open up wide opportunities for export.

Keywords: *Alternative, Energy, Sector Development, Liberated Territories, renewable*

Introduction

In recent years, the development of renewable energy sources has come to the fore as one of the priority directions of energy policy in the world. Climate change, environmental threats and the risk of depletion of fossil energy sources have accelerated the transition to alternative energy technologies. In this context, the Republic of Azerbaijan has also reconsidered its energy strategy and made the development of the alternative and renewable energy sector an important component of state policy.

One of the main directions of the new stage in the energy sector of Azerbaijan is to effectively use the alternative energy production potential of the liberated territories - Karabakh and East Zangezur. At the initiative of President Ilham Aliyev, the "Green Energy Zone" concept is being implemented in this region, which includes both regional recovery plans and environmentally sustainable energy production.

The potential of solar, wind and hydropower in the liberated territories is quite high, and using these resources, it is possible to establish the energy supply of the region not only at the level of local needs, but also in a way that can play an important role on a republican scale. This is of strategic importance in terms of accelerating economic development, as well as population settlement and the creation of sustainable infrastructure [2, p. 3].

The relevance of the topic is also related to the multifaceted goals of the region's post-conflict recovery, the establishment of a sustainable and environmentally friendly economy, attracting foreign investment, and expanding energy export potential. The main goal of the study is to analyze the mechanisms and prospects for regional development of the alternative energy sector, as well as to assess the role and importance of the liberated territories in this area.

The development of green energy sources has been identified as a priority direction in the energy strategy of Azerbaijan. This direction aims to strengthen national energy security and meet the requirements of international obligations, in particular the Paris Agreement on combating climate change and other international documents. The liberated territories have significant potential in this

regard. As a result of preliminary studies conducted in the Karabakh and East Zangezur economic regions, it was found that the average annual solar radiation in these regions is 1600–1700 kWh/m², and the average wind speed is 6–8 m/s. These indicators prove that the region has high technical and economic efficiency in terms of both solar and wind energy.

In addition, the hydropower potential of small rivers and the application of technologies with minimal environmental impact should also be taken into account. The construction of small hydroelectric power plants (HPS) on rivers in the Zangilan, Gubadli, Lachin and Kalbajar regions is possible, and this serves to diversify energy supply. Feasibility studies have already been prepared for several projects and pilot projects have been launched. All these measures do not limit the region's energy supply only to domestic demand, but at the same time create conditions for the formation of a "smart energy infrastructure" integrated into the nationwide energy network [6, p. 21].

On the other hand, the declaration of the liberated territories as an alternative energy zone creates an attractive environment for foreign investors. In 2021–2024, several international companies - especially energy companies from Saudi Arabia, the UAE and China - showed interest in this area and initial cooperation protocols were signed. Tax incentives, technical support and logistics opportunities provided by the government have further increased investors' interest in the region.

The expansion of renewable sources in the energy sector also gives impetus to socio-economic revitalization in the region. New energy projects also affect issues such as job creation, activation of the local labor market and meeting the need for qualified personnel. The opening of technical vocational schools and providing the local population with technical skills in energy constitute the social component of this strategy. All these regional approaches and strategic plans show that the development of the alternative energy sector is of great importance not only from an ecological, but also from an economic, social and geopolitical point of view. In particular, the formation of Karabakh and East Zangezur as a green energy base mark the beginning of a new stage in Azerbaijan's energy diplomacy.

Table 1.

Alternative energy potential of the liberated territories

District	Solar Radiation (kWh/m ² /year)	Average Wind Speed (m/s)	Small HPS Potential (MW)	Note
Jabrayil	1650	6.2	Low	Solar energy dominates
Zangilan	1700	7.5	Medium	Wind and solar combination possible
Gubadli	1620	6.0	Low	Favourable for solar energy
Lachin	1680	8.0	High	High potential for small hydropower plants
Kalbajar	1600	7.2	High	Favourable for hydropower and wind energy

Source: Ministry of Energy of Azerbaijan, 2023

The first table shows the technical potential of the liberated territories for alternative energy sources. The Karabakh and East Zangezur economic regions have favorable climatic indicators for solar and wind energy. In particular, in the Zangilan and Lachin regions, both solar radiation and wind speeds are distinguished by high indicators for alternative energy production. In the Kelbajar and Lachin regions, the presence of mountain rivers creates conditions for the construction of small hydroelectric power stations.

Table 2.

Alternative energy projects implemented in Karabakh and East Zangezur

Project name	Energy type	Power (MW)	Status	Partner company
Zangilan Solar Park	Solar energy	240	Planning stage	ACWA Power (S. Arabia)
Lachin Wind Power Plant	Wind energy	100	Feasibility study	Masdar (UAE)
Hekari Small Hydropower Plant	Hydro energy	10	Construction stage	Azalternativnerji
Jabrail Green Zone Development Plan	Mixed (hybrid)	-	Strategic stage	BP, IREC

Source: "Azerbaijan Alternative and Renewable Energy Agency" annual report, 2024

The second table reflects the specific energy projects planned and underway in these areas. These projects are being implemented by both local and foreign energy companies. Large-scale projects in the field of solar and wind energy are planned. In addition, the process of building small hydropower stations on the Hakkari River has been launched. Hybrid energy zones, on the other hand, provide for the joint use of different types of energy from a strategic perspective.

Table 3. Regional economic impact of alternative energy projects (forecast 2025–2030)

Economic Indicator	Expected Growth	Area of influence
New jobs created by relocation	+12,000	Energy, construction, services
Impact on regional GDP	+8%	Karabakh and East Zangezur
Foreign investment volume	+\$1.5 billion	Energy and logistics
Reduced dependence on energy imports	–10%	National energy balance

Source: Ministry of Economy of the Republic of Azerbaijan, 2024 forecast

The third table shows the expected impact of the alternative energy sector on the regional economy. As a result of these projects, thousands of new jobs will be created, foreign investment inflows will increase, and the region's gross domestic product will increase. At the same time, the expansion of alternative energy production will reduce the country's dependence on energy imports, increase the level of energy security, and contribute to environmental stability. In this regard, green energy policy is of great importance not only in terms of technological, but also in terms of social and economic development.

The liberated territories occupy a strategically and technically important place on the energy map of Azerbaijan. The Karabakh and East Zangezur economic regions have a very large potential in terms of alternative energy sources due to their natural and geographical features. The level of solar radiation, wind speed, and water resources in these areas create favorable conditions for energy production. Currently, the declaration of these regions as green energy zones and the implementation of state-level programs in this direction are aimed at realizing this potential.

In terms of solar energy, the average annual solar radiation in the Zangilan, Jabrayil, Gubadli, and Fuzuli regions is 1600–1700 kWh/m². This indicator is quite favorable for the high efficiency of solar panels. Preliminary planning has already been carried out in these regions for the construction of solar power plants and the appropriate land plots have been allocated. The exploitation of solar energy will play an important role in both the electrification of the region and its integration into the centralized energy system.

In terms of wind energy potential, the Lachin, Kelbajar and Zangilan regions stand out. The average annual wind speed in these areas varies between 6–8 m/s, which is higher than the minimum required for the economically efficient operation of wind turbines. In particular, mountainous terrain and open areas create favorable zones for the efficient production of wind energy. Another advantage of wind energy is its constant and predictable nature, which is important for balance and stability in the energy system.

The mountain rivers of the region play an important role in the production of hydroelectric power. It is considered advisable to build small-scale, environmentally friendly hydroelectric power stations on the rivers Hakari, Bazarjay, Tartar and other small watercourses located in the Kelbajar, Lachin and Gubadli regions. These stations can be used to provide sustainable energy to villages and settlements in addition to local energy supply.

In addition, the Karabakh region also has bioenergy potential. Before the occupation, agricultural and livestock activities were widespread in this area. In the post-conflict period, along with the reconstruction of these economic areas, technological opportunities will be created for obtaining biogas and other biofuels from agricultural waste. This will ensure both waste management and the use of an additional energy source.

The geographical location of the territory also creates an advantage in terms of energy transportation. Green energy exports can be carried out from the region to Nakhchivan and Turkey through the Zangezur corridor. At the same time, the implementation of energy integration projects in the South Caucasus in the context of the peace process with Armenia also increases the strategic importance of the region.

All these features indicate that the liberated territories can play a decisive role in the energy future of Azerbaijan not only on a regional but also on an international scale. The effective use of alternative energy sources will not only accelerate the socio-economic development of the region, but also strengthen the country's energy security and environmental stability.

The development of the alternative and renewable energy sector has been identified by the Azerbaijani government as a national priority. The implementation of the green energy concept, especially in the liberated territories, has been one of the main directions of state policy. By the decree of President Ilham Aliyev, the Karabakh and East Zangezur economic regions were declared "green energy zones" and complex programs have been developed to establish energy production in these regions based entirely on renewable sources [7, p. 45].

The main goal of state policy is to increase the share of alternative sources in the country's energy balance, along with ensuring the restoration and sustainable development of the territories. For this purpose, strategic roadmaps have been prepared by the Ministry of Energy and the Azerbaijan State Agency for Alternative and Renewable Energy Sources (ABOEMA), and cooperation agreements have been signed with international companies. In this context, active work is being carried out to attract both technological transfer and financial investments.

Several major energy production facilities are being planned and constructed within the framework of infrastructure projects. The 240 MW solar power plant to be built in Zangilan district will be one of the largest green energy projects in the region. At the same time, the construction of wind power plants in Lachin and Kalbajar, as well as small hydroelectric power plants on rivers, is planned. These projects are not only aimed at energy production, but are also planned to ensure the integration of energy networks into smart systems.

The construction of energy transmission and distribution systems plays an important role in the restoration and expansion of infrastructure. The introduction of smart grid technology in Karabakh will ensure the integration of local energy production into a centralized system. New power lines, substations and digital control systems will increase the stability and efficiency of energy supply in the region.

The state is implementing measures such as tax and customs concessions for investors, technical advisory support, land allocations and simplification of other administrative procedures. This approach not only increases the interest of foreign and local investors in projects, but also increases the speed of project implementation.

All these measures, as part of the state's transformation policy in the energy sector, serve to implement long-term strategies not only in terms of energy security, but also in terms of ecological, social and economic development. Through green energy infrastructure, it will be possible to implement a modern, digital and sustainable development model in the region, and this approach can serve as an exemplary model for other regions in the future.

The development of the alternative energy sector in the liberated territories of Azerbaijan is closely linked to the regional recovery process and the national energy strategy. When approaching the topic analytically, it is clear that these territories offer unique opportunities for green energy production from both a technical, geographical and geopolitical perspective. The Karabakh and East Zangezur regions are rich in natural resources suitable for both solar and wind energy, as well as small hydroelectric power plants. The efficiency of using this potential is of serious importance both in terms of regional development and diversification of the energy sector.

The energy recovery of the territory is not limited to the renewal of infrastructure and energy production. It is also directly related to the economic revival in the post-occupation period, the resettlement of the population to the region and the creation of sustainable living conditions. Alternative energy projects play the role of a locomotive for the economic development of the region. This includes both state-implemented energy production facilities and project packages offered to foreign investors. Thus, green energy is not only a technological innovation, but also an important tool of regional policy and socio-economic rehabilitation.

Analysis

The analysis shows that the green energy policy implemented by the state is formed in two main directions: first, increasing energy independence and security, and second, complying with international obligations in the field of environmental protection and combating climate change. For this purpose, the state regulates the investment climate with relevant regulatory legal acts, provides technical and financial support, and coordinates strategic infrastructure projects.

Compared to international experience, the Azerbaijani model is based more on the principle of "strategic planning + state-investor partnership". This model is suitable for the development of the energy sector in the post-conflict region, as it combines elements such as risk sharing, technology transfer, and market liberalization. However, the analysis shows that for the effective implementation of projects, security guarantees, personnel training, and long-term maintenance infrastructure in the region are also important.

Another issue is that the energy potential of these regions is not limited to meeting domestic needs. In the context of Azerbaijan's energy integration with Europe, the prospects for green energy exports are becoming increasingly relevant. In this regard, the Zangezur corridor can be an important transport-logistics and energy transmission route. That is, the energy potential of these territories is starting to gain international importance, moving from regional to international.

Consequently, the development of the alternative energy sector in the liberated territories is not just a technical project, but a multidimensional strategic process. The success of this process depends on the correct assessment of the existing potential, on the one hand, and on state policy, investment attractiveness and ensuring socio-political stability, on the other. It is with the appropriate synthesis of these factors that the Karabakh and East Zangezur regions can be formed not only as a green energy base, but also as an example of economic revival.

Continuous analysis of the topic shows that the development of the alternative energy sector has become an integral part of the reconstruction and sustainable planning processes of the region in post-conflict conditions. The integration of these territories into the energy systems is accompanied not only by the creation of new energy sources, but also by the construction of infrastructure in accordance with modern requirements, the application of digital technologies and increasing the efficiency of energy management.

The projects implemented in the territory envisage the application of smart grid systems, energy storage technologies and automated control systems. These technologies are of great importance in terms of minimizing losses in energy distribution, increasing efficiency of use and ensuring uninterrupted energy supply. This approach creates a modern and sustainable infrastructure base not only for the energy sector, but also for other economic and social sectors of the region - agriculture, industry, tourism and settlement. At the same time, the implementation of energy projects in the region also deserves attention in the context of protecting natural resources and maintaining ecological balance. Alternative energy sources act as an effective tool for reducing carbon emissions, preventing environmental pollution and combating climate change. This allows for the specific implementation of Azerbaijan's "green development" and "clean energy future" strategy at the regional level. The analysis shows that energy projects in the region are implemented not only within the framework of centralized state programs, but also with the participation of international financial institutions and the private sector. This, in turn, accelerates technology transfer, the introduction of innovations and the formation of new management models. However, at the same time, strengthening coordination and monitoring mechanisms in the implementation of projects, improving the legal and regulatory framework, and involving the local population in these processes are of particular importance.

All these points show that the development of the alternative energy sector in the liberated territories requires a complex and multifaceted approach not only in terms of energy supply, but also in terms of strategic planning, regional integration, social welfare and environmental responsibility. Proper management of this approach, in addition to being a symbol of the modern transformation of Azerbaijan's energy policy as a whole, can also contribute to the formation of a new energy and cooperation model in the South Caucasus region.

Result

The development of the alternative energy sector in the liberated territories is of strategic importance for Azerbaijan not only in the energy sector, but also in terms of the sustainable development of the national economy as a whole. The high natural potential of these regions in terms of solar, wind and hydropower create the opportunity to turn them into the main centers of green energy production. Thanks to the targeted policy implemented by the state, international partnerships and the application of technological innovations, the Karabakh and East Zangezur regions can become fully energy-independent and export-oriented zones in the near future.

Alternative energy projects have a positive impact on the restoration of infrastructure in the region, the creation of new jobs, population resettlement and environmental protection. These processes also serve to increase Azerbaijan's competitiveness in the international energy market and fulfill its commitments on climate change.

Consequently, the realization of alternative energy potential in the liberated territories is an important step for Azerbaijan in terms of long-term strategic goals - energy security, economic diversification and environmental sustainability. This approach will contribute to building a sustainable future at both the national and regional levels.

The development of the alternative energy sector in these areas also creates new opportunities for Azerbaijan's international reputation and energy diplomacy. The formation of Karabakh and East Zangezur as a green energy zone creates conditions for the country to expand cooperation in the field of energy and climate with the European Union and other international organizations. The projects implemented in these areas allow Azerbaijan to move towards the status of a "green energy center" and act as an important factor in the process of integration into the regional energy market.

On the other hand, the organization of alternative energy production in these areas also has a positive impact on the country's internal energy balance. Reducing energy imports, providing regional electricity production, and increasing the geographical diversity of energy transportation serve to strengthen energy security. This is also important in terms of reducing energy dependence and strengthening economic independence.

From a social perspective, green energy projects play an important role in improving the standard of living in the region, creating settlements equipped with clean energy, and increasing employment

opportunities for the local population. Full energy security of the region is one of the main infrastructure conditions for the return of the population.

All these factors together show that the development of the alternative energy sector in the liberated territories is not only a technological and economic issue, but also a multi-level strategic project from a geopolitical, social and ecological perspective. The sustainable and effective implementation of these projects will play a significant role in the future development of Azerbaijan and will ensure the transformation of Karabakh and East Zangezur into a region of peace, development and progress in the post-conflict period.

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Medical sciences

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RETINOBLASTOMA: THE STATUS OF THE PROBLEM AND POSSIBILITIES FOR ITS SOLUTION

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Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan***Abstract**

This scientific and analytical work presents modern clinical and diagnostic data concerning the most common malignant intraocular tumor in children – retinoblastoma. The issues of etiopathogenesis, genetic and molecular features of this pathology, assessment of the role of biomarkers in diagnostics and prognosis of the disease are covered in detail. Promising directions for the development of new and improved diagnostic and therapeutic approaches, genetic causes of this pathology, possibilities of whole genome sequencing for studying the mutation landscape, currently used classification systems of retinoblastoma, available possibilities of clinical screening are described. The publication shows that studies of the molecular basis of the disease also led to deciphering subsequent events and, thus, to the discovery of biomarkers and associated targeted therapies. In addition, improvements in molecular biology methods contributed to the development of effective methods of early diagnostics, genetic counseling and disease prevention. The issues of visual acuity assessment and improving the quality of life of patients are also comprehensively considered.

Keywords: *oncology, pediatrics, ophthalmology, retinoblastoma, incidence, etiopathogenesis, classification systems, screening, visual acuity, biomarkers, RB1 gene, DNA, genome sequencing, diagnostics, treatment, quality of life, prognosis.*

Retinoblastoma (RB) is a malignant tumor of the retina in young children.

The diagnostic criteria are as follows. Complaints and anamnesis: complaints of glow in the affected eye when exposed to light, often noticed by parents when photographing a child with a flash (white pupillary reflex, leukocoria, "cat's eye symptom"), convergent or divergent strabismus,

deterioration of vision; redness, hemorrhages, change in eye color, pain (not a typical symptom). It is necessary to clarify the duration of complaints, hereditary anamnesis.

Physical examination: general examination of the patient - pay attention to changes in the eye (glow when exposed to light, symmetry of the orbits, is there exophthalmos, is the eye inflamed, color of the pupil), assessment of the condition of internal organs and systems, palpation of peripheral lymph nodes - to exclude metastases. Mandatory referral to an ophthalmologist for a complete ophthalmological examination.

Laboratory tests: complete blood count - presence of anemia, moderate leukocytosis and accelerated erythrocyte sedimentation rate (for the presence/absence of inflammatory changes); biochemical blood test: liver function tests, levels of nitrogenous waste products, electrolytes, total protein and glucose - for radiological diagnostics using a contrast agent. Instrumental tests: ophthalmoscopy with pupil dilation under general anesthesia - is the most objective method for assessing the condition of the eye - tumor size, location, prevalence, retinal detachment, condition of the optic nerve head; retinal camera - documentation of the tumor process; Ultrasound Examination of the orbits - the presence of an intraocular formation with calcifications is a pathognomonic sign, the presence of retinal detachment, signs of growth into the orbit; Ultrasound Dopplerography of the orbits - presence of an intraocular formation with calcifications, determination of the tumor's own blood flow, detection of the "cut off branch" symptom, presence of retinal detachment, signs of growth into the orbit; X-ray of the chest organs, if necessary in two projections if pneumonia is suspected; magnetic resonance imaging (MRI) of the brain and orbits with contrast enhancement under anesthesia to determine the size of the formation, location, involvement of the optic nerve, presence of intracranial foci. In the absence of MRI, computed tomography (CT) of the brain and orbits may be performed, but this examination does not provide an objective assessment of the condition of the optic nerve and brain; according to indications, CT/MRI of other parts of the body in advanced cases with a long history [1].

RB is an intraocular tumor with hereditary and sporadic forms. 8,000 new cases of this ocular malignancy of the developing retina are diagnosed each year worldwide. The major gene responsible for retinoblastoma is RB transcriptional co-repressor 1 (RB1), and it harbors a large spectrum of pathogenic variants. Tumorigenesis begins with mutations that cause RB1 biallelic inactivation preventing the production of functional RB protein (pRB) [2].

pRB is a multifunctional protein involved in a variety of processes regulating cell proliferation at multiple levels including apoptosis, histone methylation and chromatin remodelling. Loss of function of pRB in the retina is thought to lead to dysregulation of these events, resulting in uncontrolled cell proliferation and chromosomal instability. The RB is the most common primary intraocular cancer of childhood, causing significant long-term sequelae. Loss-of-function mutations in RB1 are causally implicated in RB development. RB1 was the first tumour suppressor gene to be isolated, in contrast to activating oncogenes, which were characterised earlier. In humans, RB1 is located on chromosome 13q14.2, spans approximately 180 Kb and contains 27 exons encoding a 928 amino acid nucleophosphoprotein, known as pRB [3].

Depending on the type of mutation the penetrance of RB is different. However, in small percent of tumors additional genes may be required, such as MYCN, BCOR and CREBBP. Additionally, epigenetic changes contribute to the progression of RB as well. Besides its role in the cell cycle, pRB plays many additional roles, it regulates the nucleosome structure, participates in apoptosis, DNA replication, cellular senescence, differentiation, DNA repair and angiogenesis. Notably, pRB has an important role as a modulator of chromatin remodeling. In recent years high-throughput techniques are becoming essential for credible biomarker identification and patient management improvement. In spite of remarkable advances in RB therapy, primarily in high-income countries, our understanding of RB and its specific genetics still needs further clarification in order to predict the course of this disease and improve therapy. One such approach is the tumor free DNA that can be obtained from the anterior segment of the eye and be useful in diagnostics and prognostics. The field of ophthalmology genetics and genomics is expanding fast and the accumulated knowledge aims to develop novel and improved diagnostic and therapeutic approaches. The specific molecular mechanisms behind eye diseases, including RB, are being recognized every day, because it is important to understand their genetic causes and biological behavior in order to improve clinical outcome. Genetic implications for more than 97% of all RB cases is the RB1 gene inactivation. Although RB has been genetically characterized a long time ago, its molecular blueprint is still incomplete and needs deeper investigation. Several classification systems are currently in use, for example, the International Intraocular Retinoblastoma Classification (IIRC), International Classification of Retinoblastoma (ICRB) and cTNM (American Joint Committee on Cancer (AJCC)) and for extraocular

disease, the International Retinoblastoma Staging System (IRSS) and cTNMH staging [2].

Davies H.R. et al. [3] in their study emphasize that the majority of RB1 mutations can be detected by clinical screening. However, RB cases exist where mutations in RB1 have not been detected. Our colleagues used whole-genome sequencing to investigate the landscape of mutations in a cohort of sporadic RBs, including cases where mutations in both copies of RB1 had not been previously identified. The researchers looked for mutations in cancer driver genes and revealed a wide variety of structural rearrangements disrupting RB1. In addition, they investigated mutation burden and specific mutation patterns (mutational signatures), uncovering a treatment-related mutational signature in a tumour exposed to chemotherapy. The power of whole-genome sequencing to identify RB1 mutations of all mutation types can have significant relevance to the clinical management of RB patients and genetic counselling of their families. The development of RB is thought to require pathological genetic changes in both alleles of the RB1 gene. However, cases exist where RB1 mutations are undetectable, suggesting alternative pathways to malignancy. The authors used whole-genome sequencing (WGS) and transcriptomics to investigate the landscape of sporadic RBs derived from twenty patients, sought RB1 and other driver mutations and investigated mutational signatures. At least one RB1 mutation was identified in all RBs, including new mutations in addition to those previously identified by clinical screening. Ten tumours carried structural rearrangements involving RB1 ranging from relatively simple to extremely complex rearrangement patterns, including a chromothripsis-like pattern in one tumour. Bilateral tumours obtained from one patient harboured conserved germline but divergent somatic RB1 mutations, indicating independent evolution. Mutational signature analysis showed predominance of signatures associated with cell division, an absence of ultraviolet-related DNA damage and a profound platinum-related mutational signature in a chemotherapy-exposed tumour. Most RB1 mutations are identifiable by clinical screening. However, the increased resolution and ability to detect otherwise elusive rearrangements by WGS have important repercussions on clinical management and advice on recurrence risks.

The foundational work that explained the RB inheritance but also the concept of tumor suppressor genes was originally published by Knudson in his seminal paper from 1971 Knudson's two hit model proposed that one RB1 allele is lost or mutated in all cells and a second somatic mutagenic event affects the remaining allele in a primitive retinal cell, thus initiating tumorigenesis [4].

With an average incidence of 1 in every 18,000 live births, RB is a rare type of intraocular tumour found to affect patients during their early childhood. It is curable if diagnosed at earlier stages but can become life-threateningly malignant if not treated timely. With no racial or gender predisposition, or even environmental factors known to have been involved in the incidence of the disease, RB is often considered a clinical success story in pediatric oncology. The survival rate in highly developed countries is higher than 95% and they have achieved this because of the advancement in the development of diagnostics and treatment techniques. This includes developing the already existing techniques like chemotherapy and embarking on new strategies like enucleation, thermotherapy, cryotherapy, etc. Early diagnosis, studies on the etiopathogenesis and genetics of the disease are the need of the hour for improving the survival rates. According to the Knudson hypothesis, also known as the two hit hypothesis, two hits on the susceptibility RB gene is often considered as the initiating event in the development of the disease. Studies on the molecular basis of the disease have also led to deciphering the downstream events and thus in the discovery of biomarkers and related targeted therapies. Furthermore, improvements in molecular biology techniques enhanced the development of efficient methods for early diagnosis, genetic counseling, and prevention of the disease [5].

As noted by Byroju V.V. et al. [5] with an ability to convert electromagnetic/ light energy to electrical energy, the retina acts as a transduction screen that enables the visualisation of any object in front of it by transmitting this electrical energy as nerve impulse to the cortical functioning centres. It layers the innermost part of the eye and hosts various types of cells like rods and cones which are integral for its proper functioning. Various diseases like retinal tear, retinal detachment, diabetic retinopathy, macular degeneration, retinitis pigmentosa etc. have been associated with retina and its impaired functioning. One such disease is RB, the most common malignant intraocular tumour in children. RB is theorized to arise from the cones of the retina, which have certain properties that leave them rather susceptible to tumorigenesis. Globally, 1 in every 16,000 to 20,000 live births is known to be afflicted by RB. Most of the cases are diagnosed before the age of 5 and it accounts for 3% of all childhood cancers. Previous studies indicated that there were significant differences in the incidence of RB based on gender, ethnicity, and infections due to poor sanitation. The newer studies, however, deny significance of such differences and consider RB to have similar incidence throughout the world. Despite being rare, RB

gained interest within the scientific community since RB1 gene is the first tumour suppressor gene to be discovered. In its hereditary form, RB is associated with *de novo* mutations resulting in tumours at other foci in the body which are termed 'second primary tumours' and is attributed to the role played by phosphorylated pRB. Subjects with hereditary RBs are at a higher risk of developing other second primary tumours such as osteosarcomas, melanomas etc.. Every form of RB, familial and sporadic has the RB gene mutated to some extent resulting in the downstream processing of aberrant transcripts. RB1 gene is located on the largest acrocentric chromosome, 13 and consists of 27 exons. Following transcription, pRB is formed and gets involved in the regulation of cell cycle at the G1-S checkpoint. Phosphorylation essentially acts to 'switch off' RB tumour suppressor protein which results in deregulation of downstream molecular events that eventually results in RB.

RB has been assigned various stages depending upon the progression of the disease and its potential for metastasis. The system was named IRSS where, the stage 0 often shows good prognosis with treatment while stage IV shows poor outcome. During stage IV, the cancer is considered to be extraocular and can lead to bulging out of the eye. When it comes to differentiating it into various types, the disease can appear as unilateral, bilateral or trilateral. The chance of a patient developing a trilateral RB is 6% higher in case of bilateral RB as compared to unilateral and can be fatal in 50% of the cases. Another classification of RB could be based on direction of progression of the disease; i.e. exophytic if the tumour originates in the retina and spreads in the direction of the brain behind or endophytic if the tissue spreads in an anatomic anterior direction [5].

In addition, a very important and even decisive aspect in the early diagnosis of RB is screening. Screening of RB involves various tests for detecting the symptoms of RB. Leukocoria (sometimes referred to as the 'cat's eye reflex') can be detected by the presence of a white reflection in photographs or the red reflex test. A simpler approach would be to use mobile phones for the same purpose where, such an application exists in the form of an app called "White eye Detector" developed by Bryan Shaw. Performing cover test detects the presence of strabismus while all other signs can be identified by a systematic visual examination. Screening by an ophthalmologist is a necessity in children with a positive family history of RB. Offspring and siblings of affected patients require regular screening examinations in childhood unless genetic testing is done to rule out a gene mutation in which case the risk is similar to that of the general population. Genetic counselling for families with RB can help determine the risk to future offspring and whether other family members are at risk of developing the disease [5,6].

An ophthalmoscope view shows the optic disk, the physiological cup, the retinal vessels, the macula and the fovea centralis so the tumour is quite easily identified. Non-invasive two dimensional and three-dimensional real-time ultrasound techniques have eased detection significantly. Once the polymerase chain reaction (PCR) was invented, it became easy to identify the batch deletion of exons in chromosome no. 13 of the children whose parents carry the RB1 gene mutation. Quantitative multiplexing is an advanced form of the technique where several primers are used at the same time together to identify batch deletions. Use of X Ray and CT has found its place in detection of RB relying on properties such as calcification in the latter technique. Gadolinium contrast enhancement followed by MRI scanning is informative for tumor detection. Fat saturation is also very useful when fat has been suppressed at one time and expressed at another time in anticipation of tumor nature. T1-weighted imaging with magnetization is used for best results.

Fluorescein angiography is a technique that requires injection of a small bolus of fluorescent material into the blood stream which finally reaches the ophthalmic artery. A specialized camera takes pictures of the eye once it reaches there through the catheter using the fluorescence of the arteries of the eye as a light source. Unsuccessful attempts at detecting RB using positron emission tomography (PET) were made using Flourine-18-fluorodeoxyglucose (FDG) throughout many years. The conclusion that FDG-PET is not currently widely established and does not provide any significant advantage over MRI/CT except in metastasis rendered MRI as the gold standard. Early detection using an ultrasonogram in-utero to study the face and eyes can help in detection of the cancer, resulting in earlier detection and potential cure [7,8].

Vempuluru V.S., Kaliki S. [6] a PubMed search was performed to identify articles published with specific reference to screening of neonates, infants and children for RB. It has been established that various devices and mobile phone-based applications based on altered red reflex are finding their way into community screening. Diagnosis of RB by newborn eye screening is emphasized in several countries, and red reflex is the most widely employed technique. At the same time several screening programs for early detection of RB are evolving in the developing countries, but the practices are not uniform. Universal newborn screening should be the norm. Newer tools and software can be utilized to screen infants on a

community scale. Focussed research on revolutionizing digital imaging for a versatile screening tool holds promise for early diagnosis of RB.

RB is a cancer that can be cured if diagnosed at an appropriate time. The involvement of structures beyond the retina and the vitreous humour should be taken into consideration as they have the potential to progress into metastasis rapidly. The treatment of RB is often complex and involves decisions to be made based on a number of factors including but not limited to the size of the tumour in various axes, age of the patient, risk of secondary metastasis, previous attempts made at chemotherapy, toxicity of the chemotherapeutic agent in the subject and laterality of the tumour. Treatment of RB includes the following aspects [6,9]:

1. Enucleation. Complete removal of the eye that is affected by the tumour, or surgical excision is termed as enucleation. It is the least conservative possible management and hence reserved for cases that cannot be helped otherwise. Enucleation should be avoided in cases where salvage is possible with other treatment modalities in an effort to preserve vision and improve conservation. For the first 2 years after surgery, all patients undergoing enucleation must be carefully monitored for the risk of orbital relapse. Hydroxyapatite implants coated with specialized polymers and have attachment sites for the extraocular muscles are being implemented. Overall, enucleation was widely used and continues to be used in cases where other treatment modalities are unhelpful.

2. Intra-arterial chemotherapy (IAC). Intra-arterial chemotherapy is safe and effective enough to avoid enucleation. Modern microcatheter techniques are used to deliver chemotherapeutic agents, and success is achieved with acceptable toxicity. Drug choices for this route of administration typically include mephalan, topotecan hydrochloride, carboplatin, and methotrexate. This method is used as a primary or secondary therapeutic intervention. Although intra-arterial chemotherapy is an effective treatment option, its limitations require the introduction of more sophisticated techniques. The efficacy of IAC is reduced in cases of extensive collateral meningeal vascular presence due to dilution of the agent in these vessels. Collateral blood supply to the retina other than the ophthalmic artery is variable and affects dose delivery. Catheterization of appropriate arteries requires skill, and technical difficulties may arise that may reduce the delivery of intra-arterial chemotherapy.

3. Intravitreal chemotherapy (IVitC). Focused drug delivery to a vitreal seed hotspot is considered precision intra-vitreous chemotherapy and is an emerging technique. Often used as an adjunct therapy to IAC, in IVitC, drugs are delivered directly into the vitreous cavity in advanced stages of RB where vitreous seeding occurs. A combination of chemodrugs such as melphalan and topotecan are the preferred mode of treatment when tumour seeds recur in the vitreous and is found to be more effective than the respective individual treatments. While the presence of vitreous seeds is an indication for IVitC, contraindications include diffuse dispersion of the tumour seeds, invasion of the anterior chamber of the eye, hemorrhage into the vitreous humour, and secondary glaucoma. With the advent of nanoparticle delivery, IVitC has promising prospects in the management of RB.

4. Thermotherapy. This mode of treatment is often engaged for tumours of minor dimensions, not exclusively for the eye. The usual dimension as indicated for thermotherapy alone is of a diameter of maximum 4 mm. Diode system delivers infra-red rays either through the pupil or the sclera to destroy tumour tissue by applying focused heat to induce necrosis. Ideal temperature of thermotherapy ranges from 45-60 C. It is often used in conjunction with other treatment modalities such as chemotherapy. Complications are seen in some cases which include but are not limited to atrophy of the iris, obstruction of the retinal vein and detachment of the retina. Attempts were made to avoid thermotherapy as a single modality in cases where seeding of the vitreous humour is observed.

5. Cryotherapy. Much like thermotherapy, cryotherapy is an adjuvant and used in conjunction with other treatments. A RB tumour up to 3.5 mm in diameter and 2 mm in thickness could be treated with cryotherapy. This therapy is contraindicated in cases with vitreous seeding and any tumour that has dimensions larger than the norm. The modality involves the application of triple freeze thaw technique using liquid nitrogen.

6. External beam radiation (EBR). EBR is in the line of management of treatment for RB after enucleation as an attempt to salvage the remaining eye. A high energy photon beam or electrons are delivered at an angle where the tumour has maximum exposure. Complications include cataracts, conjunctivitis, dry eyes and intractable glaucoma. Considering side effects such as new mutations, dry eyes, keratopathy, retinopathy and optic neuropathy, EBR therapy is better restricted to extra ocular tumour extension or if better alternatives are available, this could be completely avoided. Tumours can sometimes arise secondarily due to radiation exposure, however, development of new modalities of beam radiation reduce such instances.

The authors emphasize that tumour regression should be followed up closely and the appearance, size, location, and number of tumours documented during each examination have to be assessed. When a tumour regresses after treatment, it can either appear as a white coloured calcific mass or as translucent piece of flesh. In most of the cases, patients undergo examination under anaesthesia every 4 to 8 weeks until the age of 3, followed by less frequent examinations if the disease is found to be latent.

Ancona-Lezama D. et al. [9] in their publication emphasize that RB, the most common ocular malignancy in childhood, is lethal if left untreated. RB management remains complex, requiring individualized treatment based on ICRB staging, germline mutation status, family psychosocial factors and cultural beliefs, and available institutional resources. Management of RB remains in constant evolution and treatment can vary among different centers worldwide. However, the same primary goals of protecting life and preventing metastatic disease, followed by globe preservation, and finally optimization of vision are commonly shared among RB specialists. The currently used therapies maintain excellent survival rates when disease is identified in the localized intraocular stage, while newer therapies have been focusing on additional improvement in globe preservation and providing the best possible visual acuity outcome. The refinement of these curative strategies has led to unprecedented cure rates and globe salvage in centers where a complete armamentarium of treatment options is available.

As noted in their study by Zhang R. et al. [10], RB is the most common intraocular malignancy in childhood. With the advanced management strategy, the globe salvage and overall survival have significantly improved, which proposes subsequent challenges regarding long-term surveillance and offspring screening. This cohort study included RB patients who visited Beijing Tongren Hospital from March 2018 to January 2022 for deep learning algorithm development. Clinical-suspected and treated RB patients from February 2022 to June 2022 were prospectively collected for prospective validation. Images from the posterior pole and peripheral retina were collected, and reference standards were made according to the consensus of the multidisciplinary management team. A deep learning algorithm was trained to identify "normal fundus", "stable retinoblastoma" in which specific treatment is not required, and "active retinoblastoma" in which specific treatment is required. The performance of each classifier included sensitivity, specificity, accuracy, and cost-utility. A total of 36,623 images were included for developing the Deep Learning Assistant for Retinoblastoma Monitoring (DLA-RB) algorithm. In internal fivefold cross-validation, DLA-RB achieved an area under curve (AUC) of 0.998 (95% confidence interval [CI] 0.986-1.000) in distinguishing normal fundus and active RB, and 0.940 (95% CI 0.851-0.996) in distinguishing stable and active RB. From February 2022 to June 2022, 139 eyes of 103 patients were prospectively collected. In identifying active RB tumours from all clinical-suspected patients and active RB from all treated RB patients, the AUC of DLA-RB reached 0.991 (95% CI 0.970-1.000), and 0.962 (95% CI 0.915-1.000), respectively. The combination between ophthalmologists and DLA-RB significantly improved the accuracy of competent ophthalmologists and residents regarding both binary tasks. Cost-utility analysis revealed DLA-RB-based diagnosis mode is cost-effective in both RB diagnosis and active RB identification. In conclusion, the authors point out that DLA-RB achieved high accuracy and sensitivity in identifying active RB from the normal and stable RB fundus. It can be used to surveil the activity of RB during follow-up and screen high-risk offspring. Compared with referral procedures to ophthalmologic centres, DLA-RB-based screening and surveillance is cost-effective and can be incorporated within telemedicine programs.

A very important issue is the question of preserving vision in this pathology.

Sinenko I.L. et al. [11] in their work they say that it is currently treated with a limited number of drugs, adapted from other pediatric cancer treatments. Drug toxicity and relapse of the disease warrant new therapeutic strategies for these young patients. In this study, researchers developed a robust tumoroid-based platform to test chemotherapeutic agents in combination with focal therapy (thermotherapy) – a treatment option widely used in clinical practice – in accordance with clinically relevant trial protocols. The model consists of matrix-embedded tumoroids that retain RB features and respond to repeated chemotherapeutic drug exposure similarly to advanced clinical cases. Moreover, the screening platform includes a diode laser (810 nm, 0.3 W) to selectively heat the tumoroids, combined with an on-line system to monitor the intratumoral and surrounding temperatures. This allows the reproduction of the clinical settings of thermotherapy and combined chemothermotherapy treatments. When testing the two main drugs currently used in clinics to treat RB in our model, authors observed results similar to those clinically obtained, validating the utility of the model. This screening platform is the first system to accurately reproduce clinically relevant treatment methods and should lead to the identification of more efficient drugs to treat RB.

Schaiquevich P. et al. [12] in their work they say that the management of RB, the most common

intraocular malignancy in children, has changed drastically over the last decade. Landmark developments in local drug delivery, namely, safer techniques for intravitreal chemotherapy injection and ophthalmic artery chemosurgery, have resulted in eye globe salvages that were not previously attainable using systemic chemotherapy or external beam irradiation. Novel drugs, oncolytic viruses, and immunotherapy are promising approaches in the treatment of intraocular RB. Importantly, emerging studies of the pattern of tumor dissemination and local drug delivery may provide the first steps toward new treatments for metastatic disease. Our colleagues reviewed recent advances in RB treatment, especially with regard to local drug delivery, that have enabled successful conservative management of intraocular RB, as well as emerging data from preclinical and clinical studies on innovative approaches that promise to lead to further improvement in outcomes, namely, the mechanisms and potential uses of new and repurposed drugs and non-chemotherapy treatments, and future directions for therapeutic development.

The authors emphasize that RB has been selected as a priority tumor by the World Health Organization for its Global Initiative for Childhood Cancer. Despite being highly curable at early stages, it may be fatal if left untreated. Eye-globe salvage treatments have substantially evolved over the last few decades, making intraocular RB the most curable of all pediatric cancers in high-income countries. The development of local drug delivery methods that maximize chemotherapy exposure in the retinal, subretinal, and vitreous spaces, namely ophthalmic artery chemosurgery (OAC) and a safety-enhanced technique for intravitreal (IVI) injection, have resulted in an unprecedented rate of eye globe and vision preservation. Importantly, these new local treatments result in very high concentrations of chemotherapy in the retina and optic nerve as shown in preclinical models, preventing dissemination to the central nervous system (CNS). So far, after more than a decade of continuous use at major clinical centers around the world and after more than 200 articles published in the field, IVI and OAC have been proven safe without increasing the risk of metastatic dissemination. By eliminating the use of external beam radiotherapy and systemic chemotherapy, these treatments have improved long-term survival by reducing the incidence of treatment-associated severe toxicities, the risk of secondary malignancies, and related deaths. In contrast to this exceptional improvement in treatment outcomes, children with disseminated RB have few therapeutic options, generally limited to high-dose chemotherapy, stem cell transplant, and local radiotherapy. Even worse is the scenario for patients with metastasis in the CNS, as these patients seldom survive even with intensive therapies. Thus, newer treatments and improved methods of targeting drug delivery to the CNS may improve outcomes. Examples of CNS-targeted routes include intrathecal (IT) and intraventricular (IVt) injection, which ensure direct delivery of chemotherapy to the cerebrospinal fluid, circumventing the blood-brain barrier. OAC may also be useful in patients with orbital RB with massive optic nerve and chiasmatic tumor involvement because of maximal local exposure to chemotherapy as shown in animal models. Future clinical assessments are necessary to determine the role of local chemotherapy delivery in disseminated RB. In all cases of intraocular and extraocular disease, there is a need for new therapies that are more effective and carry less risk of toxicity. New treatment modalities, namely, targeted therapies, immunotherapy, and oncolytic viruses are emerging as possible non-chemotherapeutic options. These novel treatments may further reduce the use of cytotoxic agents, potentially leading to even higher ocular preservation rates, reduced toxicities, and prevention of tumor dissemination. Identifying high-risk features associated with tumor progression and metastasis by histopathological analysis of the enucleated eye is critical for selecting appropriate management. These approaches may soon be supplemented by circulating tumor DNA (ctDNA) analysis, which may be an early and noninvasive prognostic biomarker of treatment response and risk of occult extraocular dissemination. In addition, ctDNA may be helpful in noninvasive genomic profiling, especially to identify patients with the subtype 2 molecular signature who have an increased risk of extraocular relapse. In conclusion, the researchers emphasize that treatments that have evolved over the last century have led to striking changes in the treatment paradigm for this ocular tumor. Advances in the knowledge of its tumor biology and drug response and the development of new routes of drug delivery promise to lead to additional new, more effective, and less toxic therapies in RB [12].

Warda O. et al. [13] in their work they say that the assessment of vision has a growing importance in the management of RB in the era of globe-conserving therapy, both prior to and after treatment. As survival rates approach 98-99% and globe salvage rates reach ever-higher levels, it is important to provide families with information regarding the visual outcomes of different treatments. As part of a holistic approach, it is essential for clinicians to understand the impact of various treatment modalities on vision, as severe visual impairment, particularly in bilateral cases, can negatively impact the child's development and overall well-being. Although family counselling often appropriately centres on saving

the child's life, it is important not to let the consideration of visual outcome fall by the wayside, as this is an additional piece of information that families find useful to help guide their decisions. As the authors note visual assessment in infants can be difficult. While Snellen visual acuity is used by many studies in the ophthalmic literature, this method of quantification requires children who are old enough (often over 5 years) to co-operate. Given that RB primarily affects infants and young toddlers, methods of vision assessment need to be tailored to this age group.

Age-appropriate visual acuity (VA) assessment can be performed using standard orthoptic techniques including Cardiff Cards, Keeler Cards, Kays picture tests and Single Sheridan Gardner Tests. When possible VA should be assessed monocularly. An encouraging and animated approach is used to maximise the engagement and co-operation of the child during VA assessment. As children with RB grow older, the choice of VA assessment tool should similarly evolve to ensure the most refined quantification possible. At presentation, children with RB are often seen on an urgent basis at the RB unit, which in many cases requires them to travel a significant distance. In our service, the visual assessment is performed by the orthoptist on presentation as well as at every ophthalmological evaluation during treatment; unless systemic chemotherapy, in which case visual assessment is performed after the final cycle. When RB is in remission, a visual assessment is performed at each follow-up appointment, this takes place before the examination under anaesthesia to avoid the child and family travelling great distances twice. The assessment can prove difficult particularly for starved children before their anaesthetics, so it may be necessary to settle for binocular VA in this instance. If the quantitative assessment is not possible, qualitative methods are used i.e. fixing and following a light and different-sized target to assess for a fixation preference. During the active treatment phase, the timing of visits depends largely on the treatment modalities employed. In the later years when there is no longer ongoing active RB treatment, the frequency of visits may in some cases be driven by the need to monitor for or manage amblyopia. In addition to the subjective methods of assessing VA mentioned above, electrodiagnostic studies may occasionally be helpful. Electroretinograms (ERGs), visual evoked potentials (VEPs) and fundus fluorescein angiography (FFA) have been found to be particularly useful in assessing for retinal toxicity and visual loss following the use of intra-arterial chemotherapy in eyes with tumour-free foveolae. Whilst ERGs are recognised not to correlate with vision, VEPs have a role in infants where the foveola is not involved. In fact, VEP Spatial Frequency is better than behavioural methods up to the age of 3 and is a useful adjunct to behavioural methods in this age group when assessing novel treatments and their impact on vision [13].

In addition to appropriate timely VA assessment, screening at-risk children plays an important role in optimising visual outcomes as early diagnosis correlates with smaller tumours. Consensus-based guidelines for screening are stratified by risk category, with high-risk children being screened at 2 weeks of age and repeated every 2-4 weeks initially and then at progressively long intervals until 5-7 years of age. While low-risk screeners are examined primarily within 4 weeks and follow-ups are dependent on genetic testing and are often awake examinations. In their conclusions and recommendations, the authors emphasize that with the increased rates of globe salvage, visual outcomes have become an integral part of planning the management for children with RB. In some situations, enucleation is still the most appropriate treatment, but with globe-conserving therapy, there is a need for information for patients and physicians alike to make informed decisions. Specialised orthoptic assessments to check visual acuity for children with RB has a very important role in the management of those cases. Thus, the prediction of the visual potential for both eyes needs to be tailored for each patient and be part of the parents' discussion and counselling. Tumour location and grading at presentation are the most important predictors of long-term visual prognosis. Age-appropriate visual assessments in infants and children with RB are important in safety profile data for new treatments. Families can be effectively counselled using the visual outcomes from treatment and where, appropriate visual rehabilitation and support can be provided; in particular liaison with nurseries/schools and local visual impairment teams [13].

As Gurney S.P. et al. [14] note in their work the goals of RB treatment are primarily to preserve life by curing the disease and preventing extraocular spread and distant metastases. Advances in treatment modalities over the past decades have improved survival rates and the goals have advanced further towards preserving eyes and improving visual outcomes. A cautious approach is therefore required to avoid changing a child's condition from that of an intraocular disease, when management is largely focused on avoiding incidence, to extraocular disease, when mortality is a significant concern. The authors point out that just over a decade ago, entering an eye with viable tumour was considered an absolute contraindication in most centres around the world. However, intraocular procedures on eyes with active disease are now performed routinely and safely, with an acceptably small risk of

complications. Intravitreal administration of chemotherapy is now a well-established treatment modality for vitreous disease. More invasive intraocular surgery, such as pars plana vitrectomy and endoresection have been reported by a small number of authors for atypical circumstances, including refractory disease in a child with only one eye or when a family refuses enucleation. The place of such treatment in current practice is not established and the subject of much debate. Several surgical innovations have made intraocular procedures safer and minimised the risk of extraocular spread and metastasis. These include clear corneal incisions where possible, the use of chemotherapeutic agents in irrigation fluid during surgery and delivered to entry sites (often in combination with cryotherapy) at the end of the procedure and the prophylactic use of intravitreal chemotherapy before and after surgery. It is likely that, with the further development of safer surgical techniques, the indications for intraocular surgery in active RB will continue to broaden. Likewise, the risk-benefit analysis for intraocular surgery for inactive disease may change and result in earlier interventions to improve visual outcomes or to manage the ocular sequelae of the disease or iatrogenic complications of the treatments used in the active stage of RB.

Interesting data on the contribution to scientific research on RB were obtained through a bibliometric analysis by Gu X. et al. [15]. In their study, they attempted to analyze the research trends in the field of RB and compare the contribution of different countries, institutions, journals and authors. They extracted all publications concerning RB from 2001 to 2021 from the Web of Science database. Microsoft Excel and VOSviewer were employed to collect publication data, analyse publication trends, and visualize relevant results. A total of 1,675 publications with 30,148 citations were identified. The United States contributed the most publications (643) and citations (16,931 times) with the highest H-index value (67) as of February 4, 2021. China ranked second in the number of publications (259), while ranking fourth in both citations (2,632 times) and the H-index (26) ranked fourth. The British Journal of Ophthalmology was the most productive journal concerning RB, and Abramson DH had published the most papers in the field. Keywords were categorized into three clusters; tumor-related research, clinical research, and management-related research. The keywords "intravitreal," "intraarterial," and "intravenous" appeared the most frequently, with the average appearing year being 2018.1, 2017.7, and 2017.1, respectively. Management-related research has been recognized as a heavily researched topic in the field. The study has demonstrated global trends in RB research. It has been established that the United States has been at the cutting edge of the field based on its role as the lead contributor. Despite the considerable number of publications in China, the quality of the publications requires further improvement. Novel progress can be uncovered in the British Journal of Ophthalmology and Ophthalmology. Abramson DH and Shields CL are regarded as excellent candidates for academic collaboration in the field. Chemotherapy-related research has received the most attention previously and currently; furthermore, it may still be considered in the near future as the latest hotspot.

Regarding the quality of life of patients with this pathology. Padamandala K. et al. [16] in their study note that with the increased survival of RB patients, it is important to evaluate the quality of life (QoL) of RB survivors as well as caregivers to provide comprehensive care to the children and caregivers. The aim of the study was to assess the QoL of survivors of RB, according to parents' opinions and patient self-reports, using the Pediatric QoL Questionnaire (PEDs-QoL). The study cohort included 86 RB survivors, 86 age-matched controls, and their primary carers. PedsQL 4.0 generic core scale and structured interview were administered. QoL in physical, social, emotional, and school health was evaluated and correlated with clinical and sociodemographic parameters. The mean age of the RB survivors was 5.7 years with an M:F ratio of 1.1:1. Disease was bilateral in 79% of cases. About 45% (39/86) underwent enucleation, while others received combination therapy (16; 18%), chemotherapy (30; 34%), and radiation (1; 1%). As reported by parents, the QoL of physical health domain of RB survivors was 70.2 ± 27.8 SD and 96.15 ± 13 SD, emotional health was 72.1 ± 27.4 SD and 94.4 ± 12.5 SD, social health was 80.4 ± 24.9 SD and 98.6 ± 6.2 SD; and school health was 71.9 ± 26.5 SD and 96.1 ± 12.2 SD. As per the self-report perception, the QoL of physical health was 68.2 ± 27.8 SD and 96.2 ± 13 SD, emotional health was 66.2 ± 28.4 SD and 95.3 ± 12.5 SD, social health was 69.5 ± 24.9 SD and 98.7 ± 6.2 SD, and school health was 63.5 ± 26.5 SD and 95.1 ± 12.2 SD. There was a significant relationship between enucleation and QoL domains, where $\chi^2 = 67.75$, degrees of freedom (df) = 36, and $P < 0.01$. There was a significant association between vision in the better eye (6/18 or better = 8, 6/18–6/60 = 8, 3/60 or worse = 42) and QoL scores ($\chi^2 = 95.36$, df = 62, $P < 0.01$). There was a substantial association between socioeconomic status and QoL domains, where $\chi^2 = 88.5$, df = 56, $P < 0.01$. The results of the study showed that the QoL of parents of RB survivors and self-proxy reports were negatively affected in many ways, including physical, social, emotional, and school-related dimensions. Despite the small differences, self-proxy reports indicated a lower QoL than the parents' group. The study findings

indicate that there are notable correlations between enucleation and visual acuity less than 6/18, as well as socioeconomic status, with various aspects of QoL domains among individuals who have survived RB.

Dhingra H. et al. [17] in their study mention that despite high cure rates, data on health-related QoL (HRQoL) of RB survivors are limited. This study aimed to analyze parent's perspective and self-report of HRQoL of RB survivors, using healthy siblings as controls. It also evaluated the impact of socioeconomic status (SES), gender, disease laterality, treatment modality, duration since diagnosis, and visual outcomes, on HRQoL. Ninety-two RB survivors were enrolled in this observational, cross-sectional questionnaire-based study conducted at a tertiary care center. QoL was analyzed in four dimensions: physical, emotional, social, and school, using both self-report (for children >6 years) and parent proxy report (for children 2-18 years) using Pediatric Quality of Life Inventory™ (PedsQL™) 4.0 Generic Core Scale. Seventy-seven healthy siblings served as controls. The mean age of both cohorts was 5.7 years. Thirty-six (39%) patients had bilateral RB. Of the 92 survivors, 43 (47%) had undergone enucleation. The HRQoL of RB survivors was significantly lower compared to sibling controls ($P < 0.01$) in all four domains, the physical domain being most affected followed by social domain. Parents reported an inferior QoL than patient's self-report. Vision <6/18 in the best eye and enucleation had a negative impact on HRQoL whilst gender, disease laterality, duration since diagnosis and SES had no impact. In conclusion, our colleagues draw attention to the fact that QoL assessment is often neglected but an important aspect of survivorship. The results of this study will help in formulating awareness of the domains affected and allow timely advocacy of initiatives for addressing each issue individually. Remedial measures aimed at optimizing QoL should be incorporated as part of their rehabilitation.

Reynolds M. et al. [18] in a retrospective cohort study examined the academic performance of childhood RB survivors. Seventy-three patients with RB (median age at diagnosis 9.97 months [range 0.29, 65.1]) were followed for a median of 6.4 years (0.2, 1.76). Forty-eight (65.8%) had unilateral RB. Forty-three (63.0%) received systemic chemotherapy, 57 (78.1%) enucleation. At last follow-up, 5 (6.8%) children had bilateral VA <20/70. Seventeen (23.3%) reported school difficulties and 10 (13.7%) had an individualized education program (IEP). Multivariable analysis revealed that a history of receiving chemotherapy was associated with self-reported school difficulties [(odds ratio (OR) 5.44 [1.36, 21.69], $p=0.016$)], and possessing an IEP (OR 11.47 [1.34, 98.16], $p=0.03$). Degree of visual impairment and history of enucleation did not influence the risk of self-reported school difficulties or the implementation of an IEP. Among unilateral RB patients, chemotherapy was an independent risk factor for self-reported school difficulties (OR 12.8 [1.45, 113], $p=0.009$) and implementation of an IEP (OR 15.2 [0.78, 292], $p=0.02$). As the authors state, their study is significant because it is one of the first publications to look at the incidence of developmental or school delay and evidence of disease/treatment incidence, including vision loss and hearing loss, for childhood RB survivors. Further research to assess how chemotherapy treatment impacts the cognitive development of these patients is needed. The association of chemotherapy administration and school performance could potentially be explained by several factors. Patients with chemotherapy typically have more extensive disease, thus necessitating the need for multimodality therapy. Such patients may have had more extensive local therapies or radiation, which may influence the long-term cognition of a patient. Chemotherapy was typically administered on an inpatient basis. Frequent and prolonged hospitalizations involve greater disruptions in family routines, frequent separations from siblings and peers, and time away from school which could impact cognition and school performance. A study including a greater number of patients, particularly patients with more significant vision loss, could provide more information with respect to visual acuity and developmental incidence. In addition, studies looking at developmental incidence in patients treated with intra-arterial chemotherapy, whose goal is to limit systemic chemotherapy, would be beneficial. In conclusion, the authors point out the significant fact that childhood RB survivors experience educational burdens from their disease and its treatment. Efforts to assess and monitor RB survivors for evidence of cognitive impairment is needed to identify factors associated with such incidence. Identification of such factors will assist in instituting early interventions for affected patients to improve their long-term outcomes.

To summarize the above, we can conclude that RB is the most common pediatric ocular malignancy. Despite the fact that the main attention is often paid to more common oncological diseases, it is important not to forget about the need for a specialized approach to rare forms of cancer. Peculiarities of symptoms, childhood age of patients predetermine a special approach to diagnostics of this disease; aspects of oncological alertness sometimes play a decisive role not only in early diagnostics, but also in the subsequent course of this pathology and its prognosis. Variability and veiled symptoms, its similarity with various non-core processes, cause certain difficulties and lead to neglect of the disease.

In recent years, highly effective molecular genetic examination methods have become necessary

for reliable identification of the oncological process by using biomarkers and, as a result, improving the results of patient treatment. At the same time, despite significant advances in the treatment of RB, understanding the mechanisms of disease progression, features of spread is necessary for further improvement of treatment methods and schemes. In terms of treatment tactics, innovative approaches to the treatment of this rare pathology are currently being developed, which at the same time is one of the most pressing problems at the intersection of modern oncology, ophthalmology and pediatrics.

Patients with RB also need long-term monitoring, since such patients have an increased risk of developing secondary malignant neoplasms during their life.

Screening by an ophthalmologist is a must for children with a positive family history of retinoblastoma. Offspring, brothers and sisters of affected patients require regular screening examinations in childhood, unless genetic testing is performed to exclude a gene mutation, in which case the risk is similar to that of the general population. Genetic counseling for families with retinoblastoma can help determine the risk for future offspring and whether other family members are at risk of developing the disease.

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**MORPHOFUNCTIONAL CHARACTERISTICS OF THE LIVER IN FULL-TERM NEONATES:
MORPHOMETRIC PROFILE, EXTRACELLULAR MATRIX PROTEIN EXPRESSION, AND EVALUATION
OF NON-INVASIVE FIBROSIS BIOMARKERS**

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Abstract

This study presents the first comprehensive morphometric and immunohistochemical characterization of liver tissue in full-term neonates born to healthy mothers. A total of 45 autopsy-derived liver samples were analyzed for cellular and stromal components, expression of extracellular matrix proteins, and levels of non-invasive biomarkers APRI and FIB-4. The liver parenchyma was dominated by mononuclear hepatocytes ($93.5 \pm 7.1\%$) with a low binuclearity index (0.06 ± 0.01). The stromal-parenchymal index was 0.34 ± 0.01 , and histological analysis confirmed the absence of fibrotic changes. Immunohistochemical staining demonstrated distinct localization and reproducible expression of fibronectin and collagens I, III, and IV, with type IV collagen predominantly located in sinusoidal basement membranes. Biochemical assays confirmed normal ALT, AST, and platelet levels, and both APRI (0.19 ± 0.01) and FIB-4 (0.022 ± 0.001) indices were below fibrotic thresholds. These findings offer reliable baseline data for neonatal hepatic histology and fibrosis assessment. The work establishes reference standards critical for future diagnostic and comparative studies in neonatal hepatology and supports the feasibility of applying APRI and FIB-4 as non-invasive diagnostic tools in the neonatal population.

Keywords: liver, neonate, morphometry, fibrosis, collagen, fibronectin, APRI, FIB-4, immunohistochemistry, extracellular matrix

Background. Timely identification of liver pathology in newborns remains a challenging issue in modern clinical practice. This difficulty is primarily due to the high frequency of subclinical disease progression and the nonspecific nature of early clinical symptoms [1]. Liver dysfunctions in neonates often manifest as general symptoms such as jaundice, lethargy, or coagulopathy, which do not allow timely detection of specific hepatic damage [2]. Despite the rapid advancement of molecular-genetic diagnostic techniques, pathological and morphometric analysis remains a vital diagnostic tool and continues to play a key role in verifying liver pathology in infancy [3]. However, correct interpretation of morphological changes requires reliable reference data on the normal liver structure in full-term neonates. Current literature reveals a distinct lack of such morphometric characteristics, creating a gap in evidence-based standards and complicating diagnostic standardization [4].

Objective. To provide a morphometric and immunohistochemical characterization of the main structural components of the liver in full-term neonates born to healthy mothers with physiological pregnancies, and to assess the significance of non-invasive liver fibrosis biomarkers (APRI and FIB-4) in this cohort to establish reference data and improve differential diagnosis in clinical settings [5].

Materials and Methods. The study included 45 liver biopsies from full-term neonates (gestational age 37–40 weeks) who died within the first 24 hours of life from causes unrelated to liver pathology. Morphological studies were conducted in accordance with current regulations of the Ministry of Health of Ukraine [9]. Sections were stained with hematoxylin-eosin and Mallory's method. Morphometric evaluations were performed using an Avtandilov grid at $\times 200$ magnification. Parameters assessed included the proportion of mono- and binuclear hepatocytes, structural components (hepatocytes, portal tracts, sinusoids, central veins, bile canaliculi), the binuclearity index (BIN), and the stromal-parenchymal index (SPI).

Immunohistochemical analysis included evaluation of fibronectin and collagen types I, III, and IV expression. Commercial antibody kits and automated image analysis systems (Image-Pro Plus 6.0) were used [2, 6]. In parallel, serum fibrosis biomarkers—APRI and FIB-4—were calculated using standard formulas [5, 6]. Biochemical indices (ALT, AST, platelets) were obtained from routine venous blood tests.

Results. The livers of neonates exhibited elastic consistency, homogeneous structure, and well-formed trabecular-radial architecture. Morphometrically, mononuclear hepatocytes predominated ($93.5 \pm 7.1\%$), while binuclear cells accounted for $6.5 \pm 1.2\%$; BIN was 0.06 ± 0.01 . Parenchymal components comprised $74.2 \pm 4.3\%$ of the histological field, and stromal elements— $25.8 \pm 2.6\%$; SPI was 0.34 ± 0.01 . Hepatocytes demonstrated predominantly eosinophilic cytoplasm with distinct nuclei, and in some cases, lipid vacuoles were observed [7].

Immunohistochemical analysis revealed fibronectin expression at $17.3 \pm 2.5\%$, type I collagen at $9.7 \pm 1.9\%$, type III collagen at $10.1 \pm 0.9\%$, and type IV collagen at $5.9 \pm 0.2\%$ [2, 6]. In Disse's spaces, collagen I and III types showed weak or moderate expression, while type IV collagen was localized mainly in the basement membranes of sinusoids. All markers demonstrated distinct localization and reproducible expression levels, indicating their potential as reliable markers of liver microstructural organization [2, 5].

Biochemical indicators included ALT – 12.6 ± 2.2 U/L, AST – 21.2 ± 2.7 U/L, and platelet count – $267.3 \pm 22.6 \times 10^9$ /L. APRI index – 0.19 ± 0.01 ; FIB-4 – 0.022 ± 0.001 [5, 6, 8]. These results suggest the absence of even minimal fibrosis and confirm the physiological state of the liver in control group neonates.

Discussion. The presented morphometric and immunohistochemical characteristics of liver tissue in full-term neonates born to healthy mothers represent the first comprehensive dataset of its kind [7]. The lack of comparable international literature highlights the relevance and novelty of this study [1, 3]. The obtained parameters can serve as baseline references for future comparative studies on pediatric liver pathology [4, 10]. The expression levels of fibronectin and collagens may be useful for constructing standardized fibrosis assessment scales [2, 5, 9]. Immunohistochemical visualization of connective tissue matrix allows for accurate mapping of microstructural changes in pathological conditions [6].

Despite APRI and FIB-4 biomarkers being developed for adults, this study is the first to test them in neonates, where their levels indicated an absence of fibrosis [5, 6]. The relevance of such an approach is underscored by the need for non-invasive diagnostic tools in the youngest patient population, for whom liver biopsy remains technically difficult and risky [4, 8].

Conclusions

1. Morphometric parameters and extracellular matrix protein expression levels in full-term neonatal livers can be considered reference standards.
2. APRI and FIB-4 indices in neonates may be utilized as non-invasive tools for liver status assessment in research and potentially clinical applications.
3. The obtained data significantly contribute to the evidence base for liver morphology evaluation during the neonatal period.
4. Immunohistochemical fibrosis markers enable precise localization of extracellular matrix and offer promise for early diagnosis of connective tissue changes in the liver.
5. These results may inform clinical protocol development for the management of neonates with suspected liver pathology.

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MORPHOLOGICAL CHARACTERISTICS OF SMALL INTESTINAL POLYPS AMONG RESIDENTS OF THE SOUTHERN REGION OF KAZAKHSTAN

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МОРФОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА ПОЛИПОВ ТОНКОЙ КИШКИ СРЕДИ ЖИТЕЛЕЙ ЮЖНОГО РЕГИОНА КАЗАХСТАНА

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Abstract

The present study is an experience of the histopathological spectrum of gastrointestinal polyps and its correlation with clinical and endoscopic data in the clinic.

Materials and methods: *The present study is a 10-year retrospective study from 2014 to 2024. A total of 38 cases of intestinal polyps were studied over a period of 10 years. The mean age was 50 years. The male to female ratio was 2.2:1. All relevant clinical, endoscopic and radiological data were obtained from the medical records of medical institutions. Old histological materials were re-stained and special stains were performed where required. All cases were reviewed.*

Results: *A total of 38 cases of intestinal polyps were studied over a period of 10 years. The mean age was 50 years. The male to female ratio was 2.2:1. The most common presentation system was abdominal pain. We observed both single and multiple polyps. Most of the intestinal polyps were non-neoplastic, with unremarkable mucosa or inflammatory type. In contrast to previous studies, the most common location of the hyperplastic polyp in the present study was the first part of the small-colonic intestine. Among the neoplastic polyps, the most common type was adenomatous polyp. Among the syndromes included in the study, we encountered two cases of Peutz-Jeghers syndrome and one case of familial adenomatous polyp.*

Conclusion. *Gastrointestinal polyps are rarely detected during endoscopic examinations, although most of them are non-neoplastic in nature. To exclude any neoplastic pathology and identify the risk of malignancy, a thorough examination of clinical, endoscopic data, as well as surgical and biopsy material under a microscope is required.*

Аннотация

Настоящее исследование представляет собой опыт гистопатологического спектра полипов желудочно-кишечного тракта и его корреляции с клиническими и эндоскопическими данными в клинике.

Материалы и методы: *Настоящее исследование представляет собой 10-летнее ретроспективное исследование с 2014 по 2024 год. Всего было изучено 38 случаев полипов кишки за период 10 лет. Средний возраст составил 50 лет. Соотношение мужчин и женщин составило 2,2:1. Все соответствующие клинические, эндоскопические и радиологические данные были получены из медицинских карт медицинских учреждений. Старые гистологические материалы были повторно окрашены, и там, где это требовалось, были выполнены специальные окраски. Все случаи были рассмотрены.*

Результаты: *Всего было изучено 38 случаев полипов кишки за период 10 лет. Средний возраст составил 50 лет. Соотношение мужчин и женщин составило 2,2:1. Наиболее*

распространенной системой проявления была боль в животе. Мы наблюдали как одиночные, так и множественные полипы. Большинство полипов кишки были неопухолевыми, с непримечательной слизистой оболочкой или воспалительного типа. В отличие от предыдущих исследований наиболее распространенным местом расположения гиперпластического полипа в настоящем исследовании была первая часть тонко-толстой кишки. Среди неопластических полипов наиболее распространенным типом был аденоматозный полип. Среди синдромов, входящих в исследование, мы столкнулись с двумя случаями синдрома Пейтца-Еггерса и одним случаем семейного аденоматозного полипа.

Заключение. Полипы желудочно-кишечного тракта редко обнаруживаются при эндоскопических исследованиях, хотя большинство из них по своей природе не являются опухолевыми. Для исключения любой неопластической патологии и выявления риска злокачественности требуется тщательное обследование клинических, эндоскопических данных, а также операционно-биопсийный материал под микроскопом.

Keywords: lower gastrointestinal tract, retrospective studies, Peutz-Jeghers syndrome, adenomatous polyp.

Ключевые слова: нижний отдел желудочно-кишечного тракта, ретроспективные исследования, синдром Пейтца-Еггерса, аденоматозный полип.

Интерес к проблеме полипов продиктован обнаружением и выделением генов различных форм синдромов полипоза желудочно-кишечного тракта (ЖКТ).

Синдром Пейтца-Еггерса – аутосомно-доминантно наследуемое заболевание, характеризующееся множественными гамартмными полипами в желудке, тонкой и толстой кишке, меланиновыми пигментными пятнами на коже и слизистых оболочках, а также высоким риском развития злокачественных опухолей органов пищеварения и репродуктивной системы [1,7,8].

По современной классификации множественных полипозов желудочно-кишечного тракта (ЖКТ) синдром Пейтца-Еггерса относится к наследственным гамартмным полипозам [5].

Предполагается, что клиническая гетерогенность заболевания у разных пациентов (широкая вариабельность по числу и типу полипов, плотности меланиновой пигментации кожи и слизистых оболочек, возрасту манифестации заболевания, тяжести течения) обусловлена различной экспрессивностью гена, которая, в свою очередь, зависит от типа мутации.

Синдром Пейтца-Еггерса-Турена встречается на всех континентах. Женщины болеют несколько чаще, чем мужчины. То что синдром встречается у нескольких членов одной семьи, свидетельствует в пользу его наследственного генеза [2,4,6].

Гистологически полипы Пейтца-Еггерса характеризуются характерным разветвлением гладких мышц в собственной пластинке. Однако полипы Пейтца-Еггерса тонко-толстой кишки могут имитировать полипы пролапса слизистой оболочки или практически любой полип толстой кишки, который подвергается пролапсу. Широкая вариабельность числа, размеров и гистологических типов полипов отражается в гетерогенности клинической симптоматики. В некоторых случаях множественный полипоз ЖКТ долгое время ничем себя не проявляет, манифестирует в зрелом возрасте. Описаны случаи обнаружения полипов при отсутствии какой-либо симптоматики во время обследования пациентов по поводу других заболеваний [3, 8].

Однако чаще множественный гамартмный полипоз становится причиной явных желудочно-кишечных кровотечений (гематемезис, мелена), а также приводит к оккультным кровотечениям и хронической анемии [5,6,7].

Кроме того, под влиянием перистальтики кишечника крупные плотные полипы могут тянуть за собой слизистую оболочку кишки, смещаясь на десятки сантиметров, вызывая кишечную инвагинацию с клинической картиной кишечной непроходимости. При инвагинации сокращенный участок кишки вместе со своей брыжейкой по продольной оси затягивается в дистальный отдел кишки с нормальным просветом: развивается отек, постепенно возникают нарушения кровообращения и некроз кишечной стенки [1,4,6].

Однако, ввиду отсутствия возможностей для проведения дорогостоящих молекулярно-генетических методов исследования и соответственно, их доступности, на сегодняшний день эндоскопические и морфологические данные являются решающими для диагностики, лечения и последующего наблюдения за больными с синдромами полипоза ЖКТ.

Цель исследования: На основании исследования материала полипов тонкой кишки изучить и выявить особенности их развития у молодого возраста для усовершенствования и унификации морфологической диагностики полипов тонкой кишки, также повышения ее клинической информативности.

Материал и методика исследования: На основании комплексного патологоанатомического исследования проанализировано операционного материала полипов тонкой кишки в период 2014-2024 г. Все случаи были подвергнуты патологоанатомическому исследованию в лаборатории патоморфологии КДЦ МКТУ им.А.Ясави.

Результаты исследования и их обсуждение. Макроскопически полипы могут быть плоскими или высокими, различной величины (от нескольких миллиметров до 5 и более сантиметров), с гладкой либо дольчатой поверхностью, на широком основании и на ножке [3,5,8].

Располагаются гамартомы по одиночке или кластерами, порой выстилая всю поверхность слизистой, напоминая ковровое покрытие [8,9].

Примечательно, что у больных с синдромом Пейтца-Еггера наряду с гамартомными полипами в толстой кишке и желудке часто обнаруживаются аденоматозные полипы [6].

Макроскопические проявления полипов Пейтца-Еггера напоминают таковые аденом сходного размера. Размеры были разные, их поверхность была местами гиперемирована и эрозирована, также имел разветвленной стромы.



Рисунок. 1(а,б).Значительное утолщение пораженной стенки кишечника с участками воспалением.Глубокие извитые и линейные изъязвления(придают стенки кишки вид «булыжной мостовой»)



Рисунок.2.Опухолевидное образование в подвздошной области тонкого кишечника

При гистологическом исследовании отмечалось более тесное расположение желез, и обнаруживались участки полипов, состоящие преимущественно из мелких желез с высокой пролиферативной активностью. Строма состояла из мышечной пластинки слизистой в сочетании с гиперплазированным железистым эпителием.

Изменения эпителия этих очагов помимо высокой митотической активности характеризовались многоядностью расположения ядер, выраженной базофилией и практически полным отсутствием секрета в цитоплазме клеток. Обнаруживались клетки с крупными гиперхромными или наоборот пузырьковидными ядрами и хорошо выраженными ядрышками. Помимо увеличения числа желез отмечалось их ветвление и почкование.

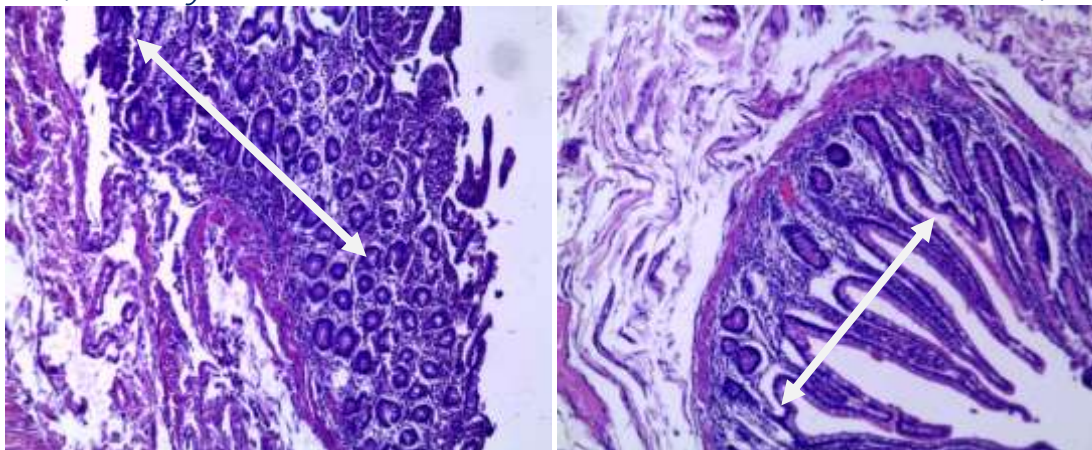


Рис.3(а,б). Операционный материал тонкой кишки, окраска гематоксилином и эозином. Ув x 200: крипты и ворсинки различной длины, разделенные ветвями гладких мышц, в эпителии клетки, характерные для слизистой оболочки тонкой кишки, – клетки Панета, энтероциты, бокаловидные клетки

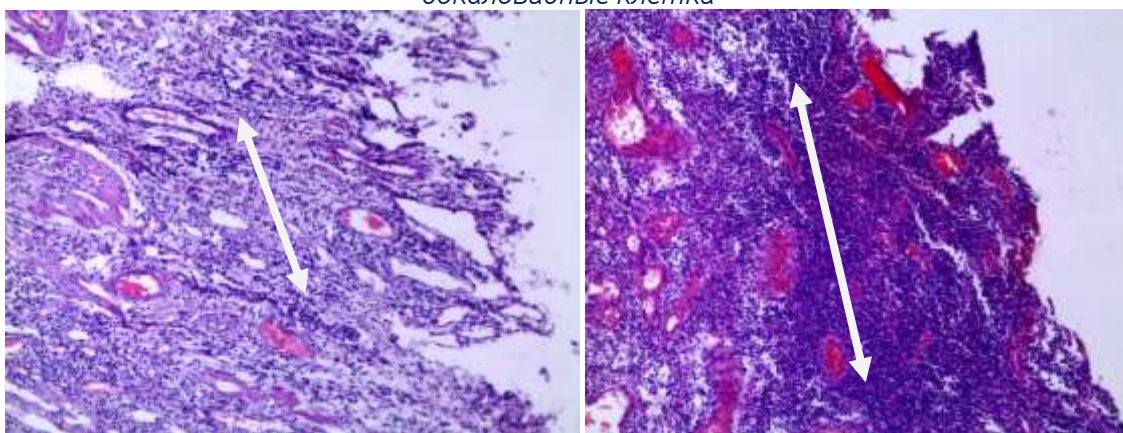


Рисунок.4(а,б). Операционный материал тонкой кишки, окраска гематоксилином и эозином. Ув x 200: Глубокий щелевидный язвенный дефект слизистой оболочки, лимфомакрофагальная инфильтрация с примесью лейкоцитов и отек ткани. Полнокровные микрососуды.

Основу данных изменений составляет пролапс мышечного слоя собственной пластинки слизистой оболочки в строму полипа с древовидным разветвлением гладкомышечных волокон, что при морфологическом исследовании создает ложное впечатление инвазии эпителия в толщу кишечной стенки [8].

Обсуждение

В настоящем исследовании большинство полипов были неопухолевыми, и большинство из них демонстрировали нормальную слизистую оболочку двенадцатиперстной кишки и воспаление при гистопатологическом исследовании. В одном случае была отмечена грануляционная ткань, а в одном случае был продемонстрирован реактивный лимфоидный фолликул. В одном случае среди неопухолевых полипов имелось гранулематозное поражение в сочетании с изъязвленной слизистой оболочкой.

Преинвазивные эпителиальные поражения тонкой кишки встречаются реже, чем их аналоги в толстой кишке. Большинство из них локализуется в двенадцатиперстной кишке, в то время как аденомы тонкой и подвздошной кишки встречаются реже, в основном из-за того, что дистальный отдел тонкой кишки эндоскопически менее доступен, а аденомы становятся

клинически очевидными только тогда, когда они вызывают обструкцию или трансформируются в инвазивные аденокарциномы[9].

Выводы

1. С точки зрения научного интереса, знание этого синдрома поможет врачу правильно и своевременно поставить диагноз.

2. При выявлении синдрома Пейтца-Еггерса-Турена необходимо обследовать всех родственников больного, что позволит выявить бессимптомно протекающие случаи данного семейного страдания, своевременно поставить диагноз и при возникновении осложнений (непроходимость кишечника, желудочно-кишечные кровотечения) с определенной степенью уверенности иметь представление об их причинах. Это, несомненно, улучшит прогноз данного заболевания.

3. Синдром Пейтца-Еггерса часто имеет осложненное течение, и больные, страдающие данным заболеванием, должны находиться под постоянным диспансерным наблюдением гастроэнтеролога, колопроктолога, онколога.

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THYROID CANCER: MODERN CLINICAL AND DIAGNOSTIC CONCEPT**Arman Khozhayev***Professor, Doctor of Medical Science,
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This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality and five-year survival rate of such a common oncological pathology as thyroid cancer. The issues of etiology and pathogenesis, modern approaches and principles of complex diagnostics, prospects for improving treatment results, as well as the prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of the regions of the country.

Keywords: *oncology, endocrinology, thyroid cancer, biomarkers, RNA, ultrasound examination, epidemiology, incidence, mortality, lethality, five-year survival rate, prognosis.*

Thyroid cancer (TC) is a malignant tumor that develops from thyroid tissue. The following diagnostic criteria for TC are distinguished. Complaints about: enlargement of the gland; appearance of a tumor on the anterior and lateral surface of the neck; change in voice (with tumor growth into the recurrent nerve); rapid tumor growth; shortness of breath, feeling of lack of air (with tumor growth into the recurrent nerve, upper respiratory tract). Anamnesis: thyroid disease (hypothyroidism, euthyroidism, hyperthyroidism, thyroiditis); long-term use of antithyroid drugs; ionizing radiation; history of radiation therapy to the head and neck. Physical examination: 1) upon examination, neck deformity (uniform swelling on the anterior surface of the neck, asymmetry due to an increase in any part of the thyroid gland, an increase in regional lymph nodes); 2) palpation examination of the thyroid gland - the presence of a nodular formation in the thickness of the thyroid gland, dense consistency; 3) palpation examination of regional lymph nodes - dense consistency, painful, mobile, immobile, partially mobile.

Laboratory tests: cytological examination; histological examination. Immunohistochemical examination: TTF-1, determination of calcitonin, fine-needle aspiration biopsy. All patients diagnosed with medullary TC or a family history of medullary TC or multiple endocrine neoplasia syndrome type 2

are recommended to undergo genetic testing to determine the germline mutation rearranged during transfection (RET) in order to determine the prognosis of the disease.

Instrumental studies: 1) ultrasound examination of the thyroid gland (determines the structure of the gland and tumor, the presence of a nodular formation, cystic cavities, size, echogenicity); the protocol for ultrasound examination of the thyroid gland includes determining the size, localization, ultrasound characteristics of the tumor; suspicious signs are (assessed only in solid nodes or in solid areas of the nodes) hypoechoic solid structure; uneven, fuzzy or polycyclic contour; point hyperechoic inclusions (microcalcifications); predominance of the anteroposterior size of the node over the width ("higher/than/wider"); 2) ultrasound examination of the cervical, submandibular, supraclavicular, subclavian lymph nodes (the presence of enlarged lymph nodes, structure, echogenicity, size); The protocol for ultrasound examination of the thyroid gland and regional lymph nodes should include assessment of the following parameters: size (it is necessary to assess the diameter or anteroposterior size, and not the length; for all cervical lymph nodes, except for level II - the fascial cellular space of the neck (submandibular zone), the largest size is no more than 0.6 cm, for level II - no more than 0.8 cm); the ratio of the long and short axes; the presence / absence of the gate; cystic changes; point hyperechoic inclusions (microcalcifications); the nature of vascularization (gate or the entire lymph node); increased echogenicity of the lymph node (similarity to normal thyroid tissue); the most specific signs that allow us to suspect metastatic lesions of the lymph node are microcalcifications, a cystic component, peripheral vascularization, and similarity of the lymph node tissue to the thyroid gland; less specific signs are an increase in size, rounded contours, and the absence of a hilum; 3) computed tomography and/or magnetic resonance imaging of the soft tissues of the neck and mediastinum (with contrast - in the presence of invasion into the main vessels, with a retrosternal location), fine-needle aspiration biopsy from the tumor (allows us to determine tumor and non-tumor processes, the benign and malignant nature of the tumor); 4) skeletal scintigraphy (prescribed if bone metastases are suspected); 5) positron emission tomography, positron emission tomography/computed tomography of the whole body (performed to diagnose the prevalence of the tumor process or the progression of the disease, or to assess the dynamics of the effectiveness of specialized treatment) [1].

The thyroid or glandula thyroidea is an endocrine gland located in the neck below the larynx in front of the trachea in mammals. In humans, it has the shape of a butterfly. It consists of two lobes connected by a narrow bridge called the isthmus. Thyroid carcinoma or TC is a malignant tumor of the thyroid gland. It is the most common malignancy of the endocrine (hormonal) system, but is very rare, accounting for about 1% of all malignant tumors, however, it has been increasing in frequency in recent years. TC is a malignant tumor of the glandular tissue of the thyroid gland. There are different types of TC that arise from different cells in the thyroid gland. TC comprises several categories: (1) differentiated TC (DTC), including papillary (PTC), follicular (FTC), and Hürthle cell tumours, (2) medullary TC (MTC) and (3) anaplastic TC. The long-term survival rate of patients with differentiated TC is about 90%, whereas patients with poorly differentiated TC types show a long-term survival rate of below 10% due to their resistance to standard treatment options [2]. The latest Global Cancer Observatory survey from 2020 reports that TC is responsible for 586,000 cancer cases worldwide [3].

Horgan D. et al. in their work they say that TC is the most common malignancy of the endocrine system that affects the thyroid gland. It is usually treatable and, in most cases, curable. The central issues are how to improve knowledge on TC, to accurately identify cases at an early stage that can benefit from effective intervention, optimise therapy, and reduce the risk of overdiagnosis and unnecessary treatment. Our colleagues focus on the fact that the approach to TC needs a rethink to early and correct identification of patients and improve their patient journey and treatment outcomes, including improved quality of life. All patients should be referred to comprehensive cancer centres. Such an approach would instate an optimal patient management mitigating overdiagnosis and overtreatment and would improve access to biomarker testing, clinical trials, and appropriate systemic therapies for patients with advanced forms of TC. It would also help establish focused national expertise on rare TC cases, promote research, training, awareness, and facilitate international collaboration [4].

Treatment and molecular testing guidelines should be regularly updated at regional and national levels to facilitate the reimbursement and availability for the most effective diagnostics and therapies. In the most recent update of the clinical practice guidelines, ESMO highlights for the first time the need to test for actionable cancer alterations in TC. It is essential that national guidelines are coordinated with the European and international ones [5].

Quality comprehensive genomic testing should be incorporated in clinical practice (tissue or liquid samples) for all TC patients that can benefit from targeted therapies. In order to facilitate correct

diagnosis, pathology practice, data collection and analysis, as well as communication with the treating physicians should be improved, with the provision of registers based on pathology. National cancer registries should distinguish specific diseases with standardised, quality-controlled systems, including details of case management and including long-term survival data. National and international data bases are needed not only for refractory TC, but for all types of TC. Thyroid gland examination practices in the asymptomatic general population need updating. With the rapid growth of big data analytics in genomics, imaging, and clinical outcomes, health systems should make it possible to generate a personalised, data-driven risk profile to customise therapy for individual patients, aiming for both long-term tumour control and manageable adverse effects [4].

Silva S.N. [6] notes that TC is not just a common type of cancer, it is the most frequently diagnosed endocrine malignancy worldwide. The etiology of TC is essentially multifactorial and radiation is the best documented risk factor related to the disease. However, many questions are still open and seeking clarification, especially regarding the genetic aspects of this pathology, with clear implications not only on a scientific basis of the disease, but foremost in clinical oncology. Thyroid gland tumours are a heterogeneous group of neoplasms that may arise from virtually any of the different cell types that are present in the thyroid gland. Although the malignant tumours are most frequently identified in thyroid follicular cells, it is clear that the molecular-genetic characterization is crucial and should be further explored to emphasize differences in tumour biological behaviours, aggressiveness, and disease prognostics. PTC and FTC represent 85-90% and 5-10% of TC cases, respectively, arising from thyroid follicular cells. These tumour histotypes retain their morphologic features and are often referred to as DTC. However, the etiology of DTC is still unknown. Considerable progress has been made in the understanding of thyroid carcinogenesis, in part based on retrospective and prospective studies published worldwide in recent decades, but also in the development of high-throughput approaches and the availability of improved diagnostic methodologies that lead to early diagnosis. In fact, over the last few decades, the research in TC has highlighted the mutational landscape leading to better understanding of the molecular pathogenesis of DTC.

The hallmarks of cancer have been identified with several potential targets involved in gene expression deregulation, leading to the promotion of genetic instability and cancer development. The identification of genetic variants related to TC has been a long way, though it is crucial to identify possible potential biomarkers of susceptibility. Some genetic variants have been identified in specific subtypes, which are related to the increased risk to develop this malignancy, such as the BRAF V600E mutation in PTC patients with a more aggressive phenotype if telomerase reverse transcriptase gene promoter mutation coexists [7].

However, mutations in RET and Retrovirus Associated DNA Sequences genes have also been identified as biomarkers in TC patients.

Alongside with genetic variants, epigenetic events and alterations in the expression of microRNA (miRNA) and long noncoding RNA (lncRNA) may also, through modulation of gene expression, drive the aberrant activation of oncogenic signalling pathways and the downregulation of thyroid-specific genes, thus contributing to the development, progression, and dedifferentiation of TC [8].

Connected to this, the genetic instability inflicted in this malignancy, involving genetic and epigenetic alterations, might also compromise the treatment response. The standard treatment for TC patients consists of surgical resection accompanied by post-thyroidectomy radioiodine (RAI) adjuvant therapy. The radioiodine therapy relies on the ability of ^{131}I to be preferentially taken up in normal or neoplastic thyroid follicular cells. Its accumulation induces high DNA damage, which leads to cytotoxicity. However, the ionizing radiation does not only affect tumour cells, but the lesions may also impair normal cells. The most common lesions induced by radiation are double-strand breaks, which are processed by enzymes involved in DNA repair pathways. The presence of genetic variants in these enzymes might impair the repair efficiency but also could influence the cytotoxic potential of RAI therapy, hence its efficacy in DTC treatment. The development of induced DNA damage approaches can help in the evaluation of the efficacy of therapeutics as it has been shown to be an important tool for establishing biomarkers of susceptibility. Although the most frequent variants identified in TC contribute to sporadic disease, about 5 to 15% of all diagnosed cases are familial (first degree relatives) in nonMTC, increasing to 25% in MTC cases. This adds to the clear existence of genetic predisposition factors related to this pathology. Advances in molecular genetics and several candidate gene studies developed worldwide have linked the occurrence of this malignancy to some hereditary syndromes, some of which are related to germline mutations in RET genes [6].

Macvanin M.T. et al. [9] in their study note that after the metabolic syndrome and its components,

thyroid disorders represent the most common endocrine disorders, with increasing prevalence in the last two decades. Thyroid dysfunctions are distinguished by hyperthyroidism, hypothyroidism, or inflammation (thyroiditis) of the thyroid gland, in addition to the presence of thyroid nodules that can be benign or malignant. TC is typically detected via an ultrasound fine-needle aspiration biopsy, cytological examination of the specimen and measurements of traditional biochemical markers, such as TSH, FT4, Tg, TgAb, and TPOAB. Novel RNA-based markers of thyroid neoplasms are identified by expression profiling of the thyroid gland tissue and/or blood samples of patients using high-throughput platforms for RNA analysis and identification, such as next-generation sequencing. Other emerging biomarkers of thyroid neoplasms are identified using flow cytometry, enzyme-linked immunosorbent assays, genetic tests, and immunohistological analyses. Due to the rapid advancement of high-throughput molecular biology techniques, it is now possible to identify new biomarkers for thyroid neoplasms that can supplement traditional imaging modalities in postoperative surveillance and aid in the preoperative cytology examination of indeterminate or follicular lesions. In conclusion, the authors draw attention to the fact that due to the rapid advancement of high-throughput molecular biology techniques, it is now possible to identify novel biomarkers for thyroid neoplasms that can supplement or replace existing biomarkers. Current circulating biomarkers, such as Tg or TgAb, are routinely used in postoperative monitoring; however, at the preoperative stage, they cannot distinguish between benign and malignant neoplasms or between low- and high-risk malignant lesions. Several new targets are emerging as potentially useful prognostic circulating biomarkers for TC. Evidence for miRNA, lncRNA and circular RNA (circRNA) dysregulation in several thyroid neoplasms and their potential use as sensitive diagnostic and prognostic biomarkers is particularly interesting. However, the data currently available in the literature is derived from small-scale clinical studies in specific patient cohorts. Thus, further validation is required to demonstrate their potential for clinical application. Large-scale studies are needed to confirm and validate novel biomarkers in the diagnosis, prognosis, and surveillance of thyroid neoplasms, such as miRNAs, lncRNAs, and circRNAs.

As they note in their work Saenko V., Mitsutake N. [10], radiation is an environmental factor that elevates the risk of developing TC. Actual and possible scenarios of exposures to external and internal radiation are multiple and diverse. In this case: 1) radiation is a risk factor for TC; the risk steadily increases up to the dose of 10 Gy, levels off in the 10- to 30-Gy interval, and asymptotically declines at higher doses but remains elevated; once exposed, the risk persists for many decades; 2) risks from the external and internal irradiation are comparable; 3) there is no evidence of dose-response departure from linearity at low doses (<0.1 Gy) and of the existence of a "safe" threshold dose; 4) the magnitude of radiation risk for TC is highest if exposure takes place at a young age; 5) after the Chornobyl nuclear reactor accident, due to internal exposure to radioactive iodine, a dramatic increase in the incidence of childhood TCs was observed, especially among children less than 5 years old at the time of the accident; 6) although many TCs were found by the thyroid-screening program after the Fukushima nuclear power plant accident, comparisons of exposures and characteristics of TC diagnosed after the Chornobyl and Fukushima nuclear accidents do not support a causative role of radiation in the latter; 7) reduction of the risk for TC may be achieved by following the As Low As Reasonably Achievable principle, and iodine thyroid blockage may be performed to protect from anticipated internal exposure. A substantial progress in understanding of radiation-related TC has been achieved since the discovery of this phenomenon about 60 years ago. Irradiation of the head, neck, and chest areas has been learned to increase the risk for developing thyroid malignancy during the lifespan. This stimulated numerous investigations in medical, industrial, and military settings whenever radiation exposure was relevant. Radiation risks have been quantified and found to be comparable for the external and internal radiation. According to this knowledge, certain groups at elevated risk could be determined, including those with medical, occupational, or emergency exposures. Now, the focus of radiation risk studies is shifting toward low-dose exposures in view of growing number of various radiological procedures, especially in pediatric patients. The markers of radiation-related TC have not been found so far. Overlaps in the histological types, oncogenic driver spectrums, and corresponding gene expression profiles between radiation-related and sporadic tumors suggest that these parameters were unlikely to serve as a marker. Clinical studies have demonstrated that TCs diagnosed in irradiated patients are of the same histological types as in nonirradiated patients and that disease prognosis is determined by tumor characteristics regardless of etiology. This is rather good news for clinicians to know that standard treatment and follow-up approaches could be used for radiation-exposed patients, but it is necessary to keep in mind that TC phenotype is changing with patient age and latency period.

Lukasiewicz M. et al. [11] emphasize that the etiology of TC is complex, and a variety of factors

contribute to its development. Among these factors, disorders of lipid metabolism have emerged as a notable area of interest. Lipids, including fatty acids (FA), play a fundamental role in cell structure and function. Consequently, disturbances in lipid metabolism can have profound effects on various cellular processes, potentially favoring the development and progression of TC. Understanding the intricate relationship between lipid metabolism disorders and TC is of paramount importance as it may provide new insights into the prevention and treatment of this malignancy. TC is a neoplasm with an increasing incidence worldwide. Its etiology is complex and based on a multi-layered interplay of factors. Among these, disorders of lipid metabolism have emerged as an important area of investigation. Cancer cells are metabolically reprogrammed to promote their rapid growth, proliferation, and survival. This reprogramming is associated with significant changes at the level of lipids, mainly FA, as they play a critical role in maintaining cell structure, facilitating signaling pathways, and providing energy. These lipid-related changes help cancer cells meet the increased demands of continued growth and division while adapting to the tumor microenvironment. Recent scientific efforts have revealed disturbances in lipid homeostasis that are specific to TC, opening up potential avenues for early detection and targeted therapeutic interventions. Understanding the intricate metabolic pathways involved in FA metabolism may provide insights into potential interventions to prevent cancer progression and mitigate its effects on surrounding tissues.

Luzón-Toro B. et al. [12] emphasize in their publication that TC, a cancerous tumor or growth located within the thyroid gland, is the most common endocrine cancer. It is one of the few cancers whereby incidence rates have increased in recent years. It occurs in all age groups, from children through to seniors. Most studies are focused on dissecting its genetic basis, since our current knowledge of the genetic background of the different forms of TC is far from complete, which poses a challenge for diagnosis and prognosis of the disease. TC is the most common endocrine cancer, with an increasing overall incidence in recent decades of about two fold in the last 25 years and accounting for 2% of all cancers. TC is the sixth most common cancer in women, who are three times more likely to have TC than men. About 2% of cases occur in children and teens. Overall, the 5-year survival rate of TC is 98%. However, survival rates depend on many factors, such as the specific type of TC and stage of disease. TC is a disease induced by progressive genetic and epigenetic molecular abnormalities. Most studies describe several classical aberrations involved in the tumorigenesis and progression of this tumor, such as point mutations, gene copy number variations, and aberrant gene methylation. The genetic landscape of TC is growing rapidly. Therapies that are targeted at genetic mutations related to this tumor are being used in patient care and clinical trials. In comparison with traditional disease-specific trials, molecular allocation studies ("basket studies") are testing targeted therapies in patients whose tumors carry particular mutations, in spite of the tumor type or origin. These studies are more informative on anticancer therapies because they include a greater number of patients. The correlation of molecular profile (obtained by new sequencing technologies) with clinicopathological characteristics will lead to the development of novel precision therapies, reducing incidence and mortality in TC patients. In this sense, differential response to a mitogen-activated protein kinase inhibitor was found to be related to the thyroid cancer genotype. Molecular testing of mutation hotspots, rearrangements, and gene expression is now an effective diagnostic tool to better select patients for potential thyroid surgery. The authors note that the diagnosis and treatment of TC is nowadays influenced by the molecular characterization of TC types. The improvement of such techniques would help to reduce the amount of TC treatment needed and improve outcomes in patients with clinically aggressive forms of cancer.

Chen D.W. et al. [13] emphasize in their work that the past 5-10 years have brought in a new era in the care of patients with TC, with the introduction of transformative diagnostic and management options. Several international ultrasound-based thyroid nodule risk stratification systems have been developed with the goal of reducing unnecessary biopsies. Less invasive alternatives to surgery for low-risk TC, such as active surveillance and minimally invasive interventions, are being explored. New systemic therapies are now available for patients with advanced TC. However, in the setting of these advances, disparities exist in the diagnosis and management of TC. As new management options are becoming available for TC, it is essential to support population-based studies and randomised clinical trials that will inform evidence-based clinical practice guidelines on the management of TC, and to include diverse patient populations in research to better understand and subsequently address existing barriers to equitable TC care.

Now, regarding this pathology in our country at the republican level. The incidence of TC in the Republic of Kazakhstan in 2023 was 5.4 per 100 thousand population (4.8 in 2022) with a growth rate of 13.1% compared to the previous year, taking 3rd place together with connective and soft tissue

tumors, second only to prostate cancer (16.7%) and laryngeal cancer (15.5%), and amounting to 1084 people in absolute numbers (939 cases a year earlier). The proportion of cases diagnosed for the first time in life, recorded by oncology organizations, was 2.9% (2.7% in 2022). In this case, 167 men fell ill (the proportion is 1.0%), women - 917 (the proportion is 4.4%) [14].

The TC rate above the national average was established in 9 regions of the country: North Kazakhstan - 12.6 (the maximum rate); East Kazakhstan - 10.6; Pavlodar - 8.5; the city of Astana - 8.2; the city of Almaty - 7.9; Kyzylorda - 7.6; Karaganda - 7.0; Akmola - 6.5; Abay - 5.9. This indicator is below the national average in 11 regions: Turkestan - 1.7 (the lowest rate); the city of Shymkent - 2.4; Atyrau - 2.6; Almaty - 3.0; West Kazakhstan - 3.8; Aktobe - 4.0; Zhambyl and Kostanay - 4.1; Ulytau - 4.5; Mangistau - 4.9; Zhetysu - 5.0 regions per 100 thousand population. Mortality from this pathology was 0.3 per 100 thousand population with an increase rate of 19.1% compared to the previous year, second only to non-melanoma skin cancer (26.0%).

The regions where the TC mortality rate is higher than the national average (0.3 per 100 thousand population) include: Abay - 1.0 (maximum level); Aktobe - 0.7; East Kazakhstan and Pavlodar - 0.5; Zhambyl, Karaganda, North Kazakhstan and the city of Almaty - 0.4. Zhetysu region and the city of Shymkent are on par with the national average. The lowest rates are noted in Atyrau and Ulytau - 0.0; Akmola, West Kazakhstan, Kostanay, Mangistau and Turkestan - 0.1; Almaty, Kyzylorda regions and the city of Astana - 0.2 per 100 thousand population [14].

One-year lethality was 2.3% (2.4% in 2022). At the same time, the ratio between one-year lethality and neglect (stage IV) was, as in 2022, 0.5, and this is the best indicator among all nosological forms of malignant tumors after prostate cancer (0.3). At the same time, we recall that the farthest from "1" is the worst ratio between one-year lethality and neglect.

Now, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were actively identified than in 2022. This is 25,193 patients versus 23,623 patients identified in 2022, i.e. +6.6%. This is due to the further abatement of the epidemiological situation with coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during routine examinations increased from 62.0% to 62.4% of the total number of patients identified over the year.

Of course, when analyzing the epidemiological situation, early diagnosis indicators are very important issues.

As for TC, the early detection of this pathology during routine examinations increased from 78.6% to 83.7%. The absolute number of TC patients identified during routine examinations was 900 people (732 a year earlier). At the same time, 849 are patients with early stages (in 2022 - 683 patients) [14].

In general, according to the amount of detected cases of cancer of all localizations, in 2023 the proportion of forms detected at early stages (0, I-II stages) increased from 66.3% to 67.9%. At the same time, detection at 0, I-II stages in TC increased from 93.3% to 94.3%. The regions where the proportion of patients with early stage I of the pathology in question is above the national average (71.5% and 2nd rank place among the best indicators after non-melanoma skin cancer) include the following regions: Kyzylorda - 85.9% (the best indicator); the city of Almaty - 84.8%; the city of Astana - 83.3%; North Kazakhstan - 80.0%; West Kazakhstan - 76.9%; Karaganda - 73.4%; Zhambyl - 72.0%; Almaty - 71.7%.

The lowest rates of early diagnosis were recorded in: East Kazakhstan - 50.6% (the worst rate); Atyrau and Turkestan - 55.6%; Mangistau - 56.8%; Zhetysu - 57.1%; Akmola - 58.8%; Aktobe - 59.5%; Ulytau - 60.0%; Kostanay - 60.6%; Abay - 65.7%; Pavlodar - 69.8% regions and in the city of Shymkent - 71.4%.

TC is in the top three in early diagnosis (stages I-II) - 92.4%. First place goes to non-melanoma skin cancer (98.4%), third - to lip cancer (90.7%). The regions where the proportion of patients with TC detected at stages I-II is above the national average (92.4% - 2nd rank place) include the following regions. The leaders are our two megacities - the city of Astana (98.2%) and the city of Almaty (97.1%). Next come: Kyzylorda - 96.9%; Zhambyl - 96.0%; Karaganda - 94.9%; Aktobe - 94.6%; Atyrau and Turkestan - 94.4%; East Kazakhstan - 93.5% regions and the city of Shymkent (92.9%). Low rates of early diagnosis were recorded in Ulytau - 70.0% (the worst result in the country); Kostanay - 72.7%; Abay - 80.0%; Akmola - 80.4%; Zhetysu - 82.9%; North Kazakhstan - 90.8%; Almaty - 91.3%; Mangistau - 91.9%; Pavlodar - 92.1%; West Kazakhstan - 92.3% regions [14].

As is clearly seen from the above data, there is a very large spread in early diagnostic rates across the country, from very good to thought-provoking. Of course, it is necessary to take into account migration processes and other factors affecting early diagnostic rates, but nevertheless, the results

obtained give reason not to stop there, both for oncologists and endocrinologists, ultrasound diagnostic doctors, otolaryngologists, and general practitioners, since improving early diagnostic rates of malignant tumors has remained one of the main postulates and one of the main tasks of medicine in general, and continues to be relevant today.

The proportion of stage IV TC among all nosological forms of malignant neoplasms was 3.9%, and this is the 4th rank place after tumors of the central nervous system (2.5%), lip cancer (0.9%) and non-melanoma skin cancer (0.4%). In general, in 2023, the share of stage IV malignant neoplasms in the republic for the sum of all nosologies decreased from 12.58 to 11.7% (from 4790 to 4735 patients). As for the average republican indicator of the share of stage IV (3.9%), Aktobe, Atyrau, West Kazakhstan regions and the city of Astana stand out against this background - 0.0%. Then come: the city of Almaty (0.6%); East Kazakhstan (1.3%); Turkestan (2.8%); Kyzylorda (3.1%) regions. Akmola region is on par with the average republican indicator. Lower indicators are in: Kostanay region, where every fifth patient with this visually accessible localization was detected in the terminal stage of the disease (21.2%). Next in line were: Abay - 14.3%, Ulytau - 10.0%, Zhetysu - 8.6%, the city of Shymkent - 7.1%; North Kazakhstan - 6.2%, Mangistau - 5.4%, Karaganda - 5.1%, Pavlodar - 4.8%, Almaty - 4.3% and Zhambyl - 4.0% regions.

The morphological verification rate of the disease in the country was 97.0%. In 13 regions out of 20 this figure is 100% (Abay, Aktobe, Almaty, Atyrau, East Kazakhstan, Zhambyl, West Kazakhstan, Karaganda, Mangistau, Pavlodar and Ulytau regions, as well as the cities of Astana and Shymkent). The lowest figure is in Kyzylorda region (68.8%). Further down the list are Zhetysu (88.6%), Kostanay (93.9%), Akmola (96.1%), Turkestan (97.2%), North Kazakhstan (98.5%) and the city of Almaty (98.8%) [14].

The total number of patients with malignant neoplasms registered with specialized oncology organizations of the republic continued to grow and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the level of the previous year (2022 - 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1055.3 to 1096.4 per 100 thousand people. The growth of this indicator is due to both the increase in the incidence and detection of pathology, and the increase in the survival rate of cancer patients. In addition, statistical data on patients diagnosed with malignant neoplasms, who have been under observation for 5 years or more, and continue to be observed in 2023, showed that the number of patients under observation by oncological organizations of Kazakhstan for over five years continued to grow and at the end of the reporting year amounted to 117,616 people, with an increase of 6.2% (2022 - 110,790 people, + 6.6%) (form No. 7).

One cannot ignore such an important clinical aspect as the coverage in the Republic of Kazakhstan of special treatment for patients diagnosed with TC for the first time in their lives. In 2023, the number of hospitalizations for all nosological forms of malignant tumors in oncological organizations of the country amounted to 108,252 cases (2022 - 101,095), with an increase of 7.1% compared to the previous year, which is associated with a constant increase in the number of cancer patients, improvement of the standardization of oncological care, and the development of palliative and restorative services. At the end of 2023, the absolute number of TC patients who completed specialized treatment amounted to 560 people, continuing treatment - 414 patients. In percentage terms, the following results were obtained by methods and types of treatment. The overwhelming majority - 90.4% of patients received surgical treatment only, complex - 3.8%, combined - 2.1%, only radiation - 0.4%, only drug - 0.2%.

Further, regarding the five-year survival rate of patients. As for TC, at the end of 2023, 9901 people or 49.8 per 100 thousand of the population were registered at the dispensary (at the end of 2022 - 9121 patients or 46.8 per 100 thousand of the population, respectively); and this is a high 7th rank place among all nosological forms of malignant neoplasms.

At the same time, the mortality rate of the observed contingents in 2023 was 0.6%, as in the previous year.

The five-year survival rate of patients with TC was 63.8% in 2023, while in 2022 it was 64.6% [14].

Summarizing the above, we can conclude that with TC, despite the fact that this localization is visually accessible, despite the increased effectiveness of preventive examinations and fairly high rates of early diagnosis, a high number of people with this pathology is noted annually, and the five-year survival rate does not reach 65%. The scarcity, variability and veiled nature of symptoms, their similarity with various non-core processes, leads to the neglect and progression of the disease, even during dispensary observation. All this requires both oncologists and, first of all, primary health care workers and, of course, endocrinologists, ultrasound diagnosticians, otolaryngologists to increase the level of oncological alertness, inform the population about early symptoms that may indicate this pathology or the onset of proliferative changes and conduct high-tech diagnostic measures, including for the purpose of differential diagnosis and, as a result, timely treatment. People from the risk group are recommended

to visit specialized specialists annually and, if necessary, undergo an examination. An epidemiological assessment of the situation with TC in our country suggests that there are sometimes significant differences in the regions not only in incidence rates, but also in the parameters of early diagnosis and mortality from this pathology. In connection with the above, this pathology continues to be a serious problem of modern clinical oncology.

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Pedagogical sciences

A MODEL OF A MODERN RUSSIAN LANGUAGE TEXTBOOK FOR UNIVERSITIES OF THE REPUBLIC OF ARMENIA

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МОДЕЛЬ СОВРЕМЕННОГО УЧЕБНИКА РУССКОГО ЯЗЫКА ДЛЯ ВУЗОВ РЕСПУБЛИКИ АРМЕНИЯ

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Abstract

The article is devoted to the analysis of current problems related to the creation and use of modern textbooks on Russian as a foreign language (RFL) for universities of the Republic of Armenia. Methodological, linguistic and cultural difficulties are considered, as well as the inconsistency of many textbooks with modern requirements of communicative methodology, digitalization and individualization of learning. The results of the analysis of the most common textbooks are presented and ways of their improvement are suggested.

Аннотация

Статья посвящена анализу актуальных проблем, связанных с созданием и использованием современных учебников по русскому языку как иностранному (РКИ) для вузов Республики Армения. Рассматриваются методологические, лингвистические и культурологические трудности, а также несоответствие многих учебников и учебных пособий современным требованиям коммуникативной методики, цифровизации и индивидуализации обучения. Приводятся результаты анализа наиболее распространённых учебников и предлагаются пути их совершенствования.

Keywords: *RFL, textbook, communicative methodology, digitalization, foreign language audience, intercultural competence.*

Ключевые слова: *РКИ, учебник, коммуникативная методика, цифровизация, иноязычная аудитория, интеркультурная компетенция.*

В последние десятилетия в РА растёт интерес к русскому языку как иностранному. Это обуславливает необходимость создания эффективных учебных материалов, адекватно соответствующих современным требованиям. Однако, несмотря на большое количество разработанных в нашей республике учебников и учебных пособий по РКИ, преподаватели-русисты, равно как и обучающиеся всё чаще сталкиваются с рядом проблем, связанных с устаревшими подходами, методологическими и содержательными недостатками современных учебных материалов для вузов Армении.

В настоящее время в связи с большими переменами, происходящими в нашем обществе, проблема содержания занятий по русскому языку в вузе приобретает особую актуальность. Можно констатировать, что многие учебники и учебно-методические пособия, изданные в начале XXI века, на современном этапе оказались совершенно неактуальными, устаревшими, неинтересными. Как справедливо отмечает А.И. Власенков, усвоение языка неразрывно связано с постижением определенных сторон окружающей действительности, и осмыслить грамматическую форму можно лишь в том случае, если при этом учат понимать связи и отношения, существующие между явлениями в реальной действительности, а объектом осмысления при изучении синтаксиса должны стать не столько структурные схемы предложений, сколько структура их смысла [1: 53].

Заметим, что многие учебники по РКИ для вузов РА, недостаточно использующие принципы коммуникативной методики, по-прежнему ориентированы на устаревший на сегодняшний день грамматико-переводной подход. Наш анализ выявил, что в большинстве учебников по РКИ для студентов-армян наблюдается отсутствие ситуационного контекста в упражнениях. Более того, нередко в учебных материалах встречается заметная перегрузка грамматическим материалом, что противоречит коммуникативному подходу к обучению иностранным языкам. Недостаточное внимание уделяется развитию продуктивных видов речевой деятельности (говорение, письмо), возможно игнорирование потребностей конкретной аудитории (например, гуманитариев, технических специалистов и т.д.), хотя основой вузовского обучения РКИ в Армении признан профессионально-ориентированный подход.

Представляется очевидным, что в условиях тотальной цифровизации образования востребованы именно мультимедийные ресурсы, адаптивные платформы и гибкие форматы подачи материала, которые во многом способствуют интенсификации процесса обучения иностранным языкам. Однако при этом значительная часть учебников не сопровождается аудио- и видеоматериалами, не разработаны интерактивные версии для платформ дистанционного обучения, отсутствует связь с мобильными приложениями и онлайн-курсами. Перечисленное значительно затрудняет использование учебников по РКИ в гибридных и онлайн-форматах обучения.

Следует отметить очевидный факт: функционирующие в образовательном пространстве РА учебники по РКИ зачастую не формируют полноценную интеркультурную компетенцию. В учебных материалах отсутствуют злободневные темы, интересующие современную молодёжь РА: политика, урбанистика, экология (в том числе экология языка), цифровые технологии, гендерные вопросы и др. Все это естественным образом заметно снижает мотивационный уровень обучающихся и не способствует культурной адаптации.

Часто учебные тексты практически не соответствуют реальной языковой практике на русском языке. Так, в учебниках, как правило, используется так называемый «учебный», а не живой язык, при этом мало внимания уделяется разговорной речи, а также жанрам соцсетей, медиа, подкастам, что в настоящее время представляется весьма актуальным. Негативный результат очевиден: учащиеся не могут применять полученные знания в реальной коммуникации с носителями русского языка.

Следует отметить, что большинство учебников построены по шаблонной схеме: текст – грамматическое объяснение – упражнения. Такой подход не учитывает разные стили обучения, когнитивные особенности, темп освоения материала. При этом востребованная на сегодняшний день индивидуализация, которая столь необходима для современных образовательных практик, во многих случаях не применяется.

Мы считаем, что для повышения эффективности вузовского обучения РКИ необходимо создание новых модернизированных учебников в ракурсе профессионализации, интеллектуализации и интенсификации процесса обучения русскому языку как иностранному, которые непременно должны опираться на:

- принципы коммуникативного и деятельностного подходов;
- цифровые технологии и интерактивные формы работы;
- адаптацию под конкретную аудиторию;
- включение аутентичных материалов и социокультурного контекста.

Нельзя обойти вниманием возможность обновления уже существующих учебников и учебных пособий с учётом текущих лингводидактических тенденций и обработке данных обратной связи от преподавателей и студентов.

Для вузов Армении, где обучаются студенты с разным уровнем владения русским языком (координативные и субординативные билингвы, носители армянского языка), целесообразно предложить модель учебника РКИ, адаптированную к национально-культурному и непременно профессиональному контексту, поскольку проблема создания модели современного модернизированного учебника по русскому языку для высших учебных заведений тесно переплетается с насущными вопросами профессионализации учебного процесса, к которым все чаще обращаются методисты-русисты нашей республики. Вопросы профессиональной ориентации учебного процесса, в свою очередь, тесно взаимосвязаны с глобальными задачами интеллектуализации и интенсификации всего учебного процесса в целом.

Отметим, что обучение русскому языку с профессиональной направленностью осуществляется практически во всех государственных вузах Республики Армения. Как

отмечает Б.М. Есаджанян, учебный процесс в вузе должен быть процессом формирования творческой личности в избранном направлении. А сформировать творческую личность можно только путем вовлечения студента в целенаправленную деятельность [2: 94].

Поскольку учебник является одним из базовых, фундаментальных компонентов учебного процесса, представляющий собой описание, презентацию и отработку всего содержания обучения на определенном этапе, а также обеспечивающим формирование умений и навыков в основных видах речевой деятельности (формирование коммуникативной компетенции), постольку его содержание однозначно должно отражать все вышеперечисленные злободневные проблемы. Однако основным стержнем содержания учебника или учебно-методического пособия по РКИ для вузов Армении, на наш взгляд, должна стать профессиональная ориентация языкового материала, обеспечивающая стабильную мотивацию учебного процесса.

Модернизированный учебник по русскому языку для вузов, соответствующий современному этапу, должен быть адекватен запросам студентов, удовлетворять их необходимые жизненные потребности и быть направленным на формирование коммуникативной компетенции в целом, и в области будущей специальности, в частности, которая реализуется в различных видах речевой деятельности, связанной с восприятием и порождением речи. Информативный материал должен быть актуальным, интересным, познавательным, иметь интеллектуальную и языковую ценность, а также включать определенное количество профессиональных терминов и терминологических сочетаний.

Интересное содержание обучения дает возможность создать на уроке соответствующую эмоциональную обстановку, а одновременное задействование мыслительных и эмоциональных каналов при восприятии материала является очень важным условием не только для более прочного и сознательного усвоения знаний, но и для формирования убеждений, обеспечения единства воспитания и обучения [3: 12].

Принципиальными положениями, которые должны приниматься во внимание при создании современных модернизированных профессионально ориентированных учебников по русскому языку как иностранному для вузов, должны стать следующие:

- коммуникативно-ориентированное обучение с профессиональной направленностью;
- национально и поликультурно ориентированное обучение;
- интеллектуализация учебного процесса, подразумевающая развитие личности, основанное на познавательном интересе, который выступает в качестве очень значительного мотива – внутреннего побуждения деятельности учащихся, и в этой роли его невозможно переоценить [5: 10];
- изменение отношения к обучаемому как к активному субъекту обучения, находящемуся в партнерских отношениях с обучающим;
- реализация личностно ориентированного подхода к обучаемому в учебном процессе;
- связь изучения иностранного языка с поведением человека в языке, с его когнитивно-коммуникативной деятельностью на этом языке, с его способностями, возможностями и умением найти определенную стратегию поведения для решения вербальных и невербальных задач в каждой возникающей ситуации;
- использование на уроках возможностей внешнего и внутреннего сопоставления языкового материала [4:133].

Таким образом, принципиально новая современная система обучения русскому языку требует новых подходов к обучающимся, а также их (подходов) мотивационно-стратегической реализации в учебном процессе, что, несомненно, должно найти отражение в моделях новых модернизированных учебников и учебно-методических пособий.

В настоящее время в лингводидактике одним из важнейших направлений является личностно ориентированный подход к учащемуся в системе обучения русскому языку в национальной аудитории, который являет собой индивидуальный подход к обучаемому как к особой личности.¹ В современной методике преподавания русского языка как иностранного личностно ориентированный подход разрабатывается довольно активно с целью максимальной индивидуализации обучения. Ведь важнейшим средством повышения эффективности аудиторного и автономного усвоения языка является развитие учебных и коммуникативных стратегий – умений учиться и общаться, которые формируются у субъекта в ходе усвоения родного языка и входят в состав его коммуникативной компетенции в виде исходной формы стратегической компетенции. В нее также включаются универсальные метакогнитивные стратегии – умения организовать свою учебную деятельность, а также

аффективные (эмоциональные) и социальные стратегии. На наш взгляд, учет личностно ориентированного подхода при создании учебников по РКИ приведет к максимальной отдаче и будет способствовать эффективному усвоению предложенного языкового и речевого материала. Данный подход предполагает активную направленность модели нового модернизированного учебника на обучаемого, стимулирование активного, самостоятельного усвоения материала и целенаправленное формирование и развитие новых умений и навыков, совокупности природных компетенций, проявляющихся в способности обучаемых анализировать, синтезировать, сопоставлять предлагаемый материал, интегрировать, переносить и использовать полученные знания в разных жизненных ситуациях. Такая широкая обращенность к обучаемому создает условия для более активного и самостоятельного усвоения материала учащимися.

Что касается отбора и презентации содержания учебника, наиболее актуальным представляется реализация современных теоретически обоснованных когнитивно-коммуникативных и прагматических подходов к обучению иностранным языкам. При этом, на наш взгляд, основной упор должен делаться на формирование активности обучаемого, развитие его личностной и социальной ответственности, осознание целей и самооценки результатов обучения.

Исходя из всего вышесказанного, характерной особенностью современного модернизированного учебника должна стать его активная направленность на обучаемого, стимулирование самостоятельного усвоения учебного материала и целенаправленное формирование и развитие умений и навыков, совокупности природных компетенций, проявляющихся в способности обучаемых анализировать, синтезировать, сопоставлять предлагаемый материал, интегрировать, переносить и использовать знания в разных жизненных ситуациях. Такая широкая обращенность к обучаемым создает условия для активного и самостоятельного усвоения языкового материала.

В современной модели нового учебника русского языка для вузов должны быть отражены новые подходы к представлению языкового материала, что позволит увидеть место того или иного грамматического фрагмента в общей системе изучаемого языка. При этом нередко следует использовать сопоставительно-типологические или контрастивные характеристики данного языкового явления, а также реализовать возможности внутреннего сопоставления языкового материала [4: 134].

До настоящего времени учебники по РКИ для вузов практически не иллюстрировались. Однако современные технические средства предлагают широкие возможности размещения различных иллюстраций и других разнообразных наглядных материалов, что, несомненно, сделает новый учебник более актуальным и интересным, поскольку тщательно и грамотно подобранный, а также эффектно размещенный иллюстративный материал (рисунки, фотографии, символы и пр.) позволит опираться не только на логическое и ассоциативное мышление, но и на эмоциональное восприятие учащихся, что сделает работу по учебнику более интересной и эффективной. Таким образом, в данном случае наличествует также активное и постоянное вовлечение положительного эмоционального фактора в учебный процесс, что также способствует формированию стабильной мотивации обучения.

Целевыми установками модели учебника по РКИ для вузов Армении должны стать следующие:

- формирование профессионально-коммуникативной компетенции на русском языке.
- учет национального, лингвокультурного и билингвального контекста армянских студентов.
- подготовка студентов к профессиональному взаимодействию с русскоязычными коллегами.
- развитие академических и социокультурных навыков, необходимых для профессиональной мобильности.

В предлагаемой модели учебника русского языка для вузов должен быть представлен широкий выбор ориентиров, обеспечивающих глубокую проработку и освоение языкового материала (тесты, диалоги, иллюстрированные ситуации, творческие задания, разнообразные схемы и грамматические таблицы, отражающие не только языковые явления русского языка, но и дающие типологические и контрастивные характеристики на материале двух (русский, армянский) языков. Все это будет способствовать активизации осознаемых и

неосознаваемых, контролируемых и неконтролируемых процессов овладения русским языком студентами вузов.

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Physical sciences

TIME TRAVELS IS NOW PHYSICALLY POSSIBLE¹

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Abstract

The theme of time travels has now been successfully mastered mainly by science fiction writers. The official position of science on this problem is as follows: although the possibility of time travels by the laws of physics is not excluded – teleportation in quantum mechanics, “twin paradox” in the special theory of relativity, “mole burrows” in the general theory of relativity, etc. – it will not be possible to create a time machine either now or in the distant future.

However, this article provides descriptions of time travel realisations that are already physically feasible on Earth now.

Keywords: imaginary numbers; special theory of relativity, invisible universes and anti-universes, hidden Multiverse, Hyperuniverse, portals, anomal zones

1. Introduction

The XX century in physics was rich in new interesting scientific ideas. But many of them, even called theories, have not yet received experimental confirmation. And one of such scientific theories studied now in all physics textbooks is the special theory of relativity (STR) [1]-[3], which has been nominated 66 times for the Nobel Prize, but due to the lack of its experimental confirmation has not received it.

And the article proven that this version of STR is incorrect, as relativistic formulas received in it are incorrect, they are incorrectly explained with use of incorrect principle of non-exceeding of speed of light and from them incorrect conclusions about physical unreality of imaginary numbers, and also about that in the nature there is only our visible universe. Nevertheless, this incorrect version of STR is now taught in all physics textbooks.

In the article also the basic provisions of the corrected version of STR [4]-[11] are stated, from relativistic formulas of which and new scientific knowledge received after creation of the incorrect version of STR, it follows that in the nature there exists not only our visible universe, but also many other mutually invisible universes and antiverse. And in addition to matter, space and time in the universes. antimatter, anti-space and anti-time exist in the antiverse. Therefore, travelling is possible not only in space, but also in time. The article explains how to realise them.

2. Time travelling with using the nature of the Earth

The purpose of this publication is an attempt to show that time travel for people on Earth is already quite feasible. At the same time, let us specify at once what kind of time we are talking about. About the fact that for each person there are two different kinds of time – his internal biological time, as a resource independent of the environment, and external time for the processes occurring around him in the environment. And it is possible to travel only in external time. Internal time cannot flow backwards. A person cannot return to his childhood.

But the situation in the external environment in which a person is, can change in the most incredible way, including under the influence of people. And in this external environment it is possible to move both to the future and to the past time. And even short-term movements in time can be very useful. For example, if you get an opportunity to look into the future at least for a short time, you can make a better choice in the present. Or, by travelling to the past, you can fix something.

And such external time for people on the Earth exists. These are 24 time zones, which are generated by the rotation of the Earth around its axis. Moving through them in space, people also move in time. And depending on the direction of movement in space – to the West or to the East – they can move both to the past and to the future time. This is well known to everyone, but it is not used in human activity yet.

And it's a free resource for solving the problem of human time travel that isn't even difficult to use. In fact, to travel back in time, for example, 24 hours, all you have to do is move east 24 time zones. To travel into the future, you would have to do the same thing, but only by travelling west. All this is not

difficult to do. It is also necessary to take into account that crossing one time zone will take less time, the closer to the pole – regardless of which one, north or south – the transport route of time travellers will run. Therefore, it will be more favourable to lay it closer to the poles (for example, at a distance of 200-1000 km from the pole around the pole).

In this variant of time travelling everything is clear. Therefore, the experiment on its realisation can be done as follows. Suppose that in one of the South American countries the president is assassinated. Then the head of the security service gets on a plane and, having flown around Antarctica in 24 time zones, lands a day in the past at the same aerodrome from which he took off. The external time for him changed into the past by 24 hours, and the internal biological time changed into the future, for example, by 10 hours. That is, the head of the security service arrived in time 14 hours before the attempt on the president's life. And then during this time he will have time to take the necessary measures to save the president¹ and arrest the criminals.

And if the result of this simple experiment turns out to be positive, there will be a great interest in the practical use of time travel. Then the problem of creating a time machine capable of comfortably realising more complex and longer time travel routes will inevitably become urgent. But at the same time it will be necessary to recognise that the generally recognised version of the special theory of relativity (STR) studied in all physics textbooks is incorrect, as it states that there is only our visible universe in nature, in which there are no portals.

3. The version of STR taught in all physics textbooks is incorrect

Since STR, created more than 100 years ago, is now studied in all universities, even the most prestigious ones, and is used in very expensive scientific research (including the Large Hadron Collider), its criticism must be impeccably evidentiary.

So, let's prove on such conditions that the generally recognised version of STR is incorrect [12]-[40], since:

- the relativistic formulas obtained in it are incorrect;
- they are incorrectly explained using the incorrect principle of non-exceedance of the speed of light;
- from the wrong relativistic formulas the wrong conclusions about existence in the nature of our only visible universe and physical unreality of imaginary numbers are made.

Indeed, after the creators of STR got their relativistic formulas,

$$m = \frac{m_0}{\sqrt{1 - (v/c)^2}} \quad (1)$$

$$\Delta t = \Delta t_0 \sqrt{1 - (v/c)^2} \quad (2)$$

$$l = l_0 \sqrt{1 - (v/c)^2} \quad (3)$$

in which m_0 - is the rest mass of a moving body (for example, an elementary particle):

m - relativistic rest mass of a moving body;

t_0 - the rest time of the moving body;

t - relativistic time of a moving body;

l_0 - rest length of a moving body;

l - relativistic length of a moving body;

much of what they did afterwards had already been done incorrectly.

¹ It is possible that President Kennedy could have been saved in a similar way at one time.

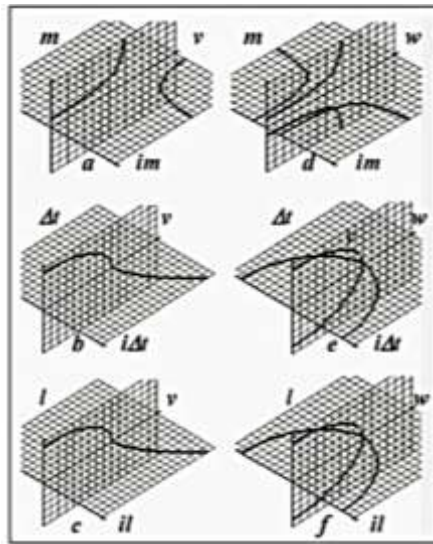


Fig 1. Graphs of functions $m(v)$, $\Delta t(v)$, $l(v)$ corresponding to the existing and corrected versions of STR in the sublight $v < c$ and hyperlight $v > c$ ranges

Firstly, the authors of STR did not realise that the value v appearing in these formulas according to Newton's first law is the fourth, besides length, width and height, spatial dimension. And therefore relativistic formulas necessarily should be explained not only in sublight $v < c$, but also in hyperlight $v > c$ ranges.

Secondly, not being able to explain the physical meaning of imaginary values of quantities $m(v)$, $\Delta t(v)$, $l(v)$ in the hyperluminal range $v > c$ and in order not to admit it², they introduced into STR an incorrect postulate called the principle of unexceeded speed of light.

Thirdly, they did not pay attention to the fact that the formula (1) in the hyperluminal $v > c$ range corresponds to a physically unstable process, which cannot exist in the nature. And, consequently, the relativistic formulas (1)-(3) are incorrect.

Fourthly, as it will be proved further, the statement of STR about physical unreality of imaginary numbers is incorrect, and therefore the following from it principle of non-exceeding of speed of light and the statement about existence in the nature of our only visible universe are also incorrect.

And therefore the version of STR studied in all physics textbooks is incorrect.

And, although it was never written about³, in fact, the universally recognised version of the STR was refuted before its creation by Charles Proteus Steinmetz's interpretation of Ohm's⁴ law for alternating current circuits published in 1893 [41], which is now used daily by millions of electrical and radio engineers around the world in their practical activities.



Fig. 2. In any radio-technical laboratory there are devices called frequency response meters, which by their mere existence prove the physical reality of complex frequency responses and, consequently, of any other imaginary and complex numbers. And thus they make the failed OPERA experiment unnecessary.

² Since no one would want a theory that even its authors couldn't explain.

³ Because in 1893-1905. STR didn't exist yet.

⁴ And in the original author's interpretation of this law for electric circuits of direct current Georg Simon Ohm was formulated after 9 years of experimental research in 1826, when there were not yet any electrical measuring devices. And in 1828 Ohm was dismissed from his job by the Minister of Education for publishing his research. The high-ranking official believed that the use of mathematics in physics was unacceptable.

At the same time, of course, proving its validity. Indeed, in the formulation of Ohm's law proposed by Steinmetz, it is stated that not only resistors, but also capacitors and inductors (also called inductance coils) have electrical resistance. But the resistance of resistors is measured by real numbers R , and the resistances of capacitors and inductors are measured by imaginary numbers⁵ $-1/j\omega C$ and $j\omega L$.

Therefore, linear electric LCR-circuits of any configuration possess resistance measured by complex numbers. Consequently, its value and the value of the current flowing through such a circuit in accordance with Ohm's law in the interpretation of Steinmetz depend on the frequency ω of the sinusoidal voltage applied to this electric circuit. And this makes it possible to perform a very simple but very important experiment, which will allow us to confidently answer the question whether imaginary numbers are physically real. After all, if imaginary resistances of capacitors and inductance coils are physically unreal, their inclusion in electric circuits should not affect the results of LCR-circuit resistance measurements. The measured resistance of the LCR-circuit in this case will always be measured in real numbers and will not depend on frequency. Conversely, if the imaginary resistances $-1/j\omega C$ and $j\omega L$ are physically real, then when the frequency ω of the voltage applied to the LCR-circuit changes, the magnitude of the current flowing through it will change due to the change in the value of its resistance. And all electrical and radio engineers know that the resistance of LCR-circuits always depends on the frequency of the voltage applied to them. Which proves the physical reality of imaginary numbers in the most indisputable way. After all, it is only possible to measure what actually exists in nature. Therefore, most of what we know about the world around us, we have learnt with the help of instruments – in physics, biology, chemistry and all other sciences.

And in radio engineering, instruments for recording such measurements have long been created and commercially produced - oscilloscopes, frequency response meters, spectrum analysers and others. Even many radio amateurs possess the simplest of such devices - a tester, which allows to measure the capacitor capacitance value. In fact, in accordance with Ohm's law as interpreted by Steinmetz, the tester measures the imaginary value of electrical resistance of the capacitor and recalculates it into the capacitance value.

There are other proofs of physical reality of imaginary numbers [42]-[53].

And from the experimentally proved principle of physical reality of imaginary numbers it follows that the postulate about not exceeding the speed of light and the conclusion made with its use about the existence in nature of our only visible universe, in which everything is measured only by real numbers, are incorrect.

4. Corrected version of STR

Therefore, the relativistic formulas (1)-(3) should be explained in the hyperluminal velocity range $v > c$ also. Moreover, since they are incorrect in this speed range, they need to be fixed first. And remembering Newton's first law, it's clear how the formulas (1)-(3) must be corrected. To make them look like the graphs in Fig. 1d,e,f, similar to the graphs in Fig. 1a,b,c in the range $v < c$, a multiplier i^q must be introduced into them.

$$m(q) = \frac{m_0 i^q}{\sqrt{1 - (v/c - q)^2}} = \frac{m_0 i^q}{\sqrt{1 - (w/c)^2}} \quad (4)$$

$$\Delta t(q) = \Delta t_0 i^q \sqrt{1 - (v/c - q)^2} = \Delta t_0 i^q \sqrt{1 - (w/c)^2} \quad (5)$$

$$l(q) = l_0 i^q \sqrt{1 - (v/c - q)^2} = l_0 i^q \sqrt{1 - (w/c)^2} \quad (6)$$

where $q(v) = \lfloor v/c \rfloor$ is the "floor" function of discrete mathematics (see Fig. 3a) of the argument v/c ;

$w = v - qc$ is the local velocity for each universe (see Fig. 3b).

This is a convenient function⁶ to explain, since for integer values of the argument $0, 1, 2, 3, 4, 5, \dots$ it takes the alternating values we need $+1, +i, -1, -i, +1, +i, \dots$ corresponding to four different types of universes

⁵ In electrical engineering and radio engineering, the imaginary unit is denoted by the letter j , since the letter i denotes electric current.

⁶ But the i^q function has the disadvantage that it is defined only for integer values $0, 1, 2, 3, 4, 5, \dots$ of the argument q . Nevertheless, since for these same argument values the Euler formula $e^{iq\pi/2} = \cos(q\pi/2) + i\sin(q\pi/2)$ also takes the same values, then for non-integer argument values the i^q function can be calculated by the formula $i^q = \cos(q\pi/2) + i\sin(q\pi/2)$. The latter

alternating in space. The value $q=0$ corresponds to our visible universe (since for it $i^0 = 1$). And the value $q=1$ corresponds to another universe (since for it $i^1 = i$), which is invisible to us due to the condition $v > c$, since it is located beyond the event horizon. Stephen William Hawking wrote about imaginary time in such a Multiverse: "Imaginary time is a new dimension, at right angles to ordinary real time". And thus, with his research, he confirmed the validity of the hypothesis of a hidden Multiverse considered below.

For the sake of certainty, we will call this corresponding $i^1 = i$ universe tachyon⁷, since it contains tachyons, which are understood to be subatomic particles moving at a speed exceeding the speed of light. But many physicists believe that they should not exist in nature (understood to be the Monouniverse corresponding to the generally accepted interpretation of STR), since they violate the principle of causality. And since tachyons are actually not in our universe, but in the tachyon universe (or antiuniverse), they do not actually violate the principle of causality. And, therefore, they do exist.

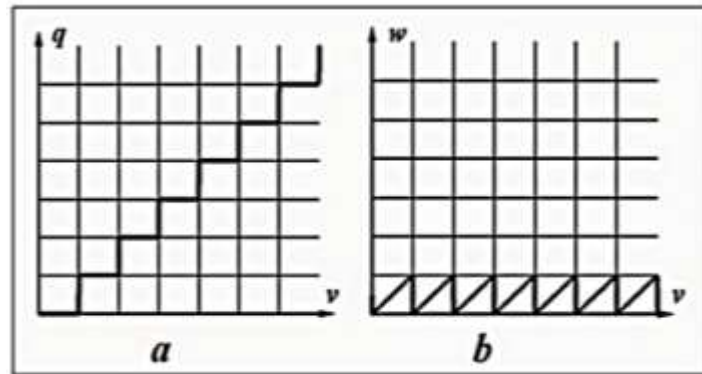


Fig. 3. Graphs of the functions $q(v)$ and $w(v)$, illustrating the meaning of the "floor" function of discrete mathematics

For similar reasons, we will call our universe tardyon⁸. And then it will be logical to assert (see Fig. 4) that the value $q=2$ corresponds to an invisible tardyon antiuniverse (since for it $i^2 = -1$), the value $q=3$ corresponds to an invisible tachyon antiuniverse (for which $i^3 = -i$), the value $q=4$ corresponds to an invisible other tardyon universe (for which $i^4 = 1$) the value $q=5$ corresponds to an invisible other tachyon universe (for which $i^5 = i$). And so on.

We will therefore call such an invisible Multiverse hidden [54]-[70]. Its open helical structure distinguishes it from numerous other Multiverses, some of which are described in [71]-[79].

Then a natural question arises for her: what is beyond these edges? And this question is similar to the question that arose even among ancient people - what is beyond the edges of our flat, as they believed then, Earth. But the answer to the latter question was never received, since the Earth, as it later turned out, has an almost spherical shape. More precisely, the shape of an ellipsoid of rotation, i.e. a geoid. Therefore, it has no edges. But our questions remain - so what is beyond the edges of the screw structure of the hidden Multiverse. And it will be logical to assume that beyond the edges of the hidden Multiverse, shown in fig. 4, there are other Multiverses, not shown in the figure for simplicity.

It is also time to answer one more natural question - in what space such parallel universes of the hidden Multiverse exist, if they do not intersect? The answer to it can be only one - in the space having more than three dimensions. This circumstance in formulas (4)-(6) is taken into account by the parameter q , which is the fourth spatial dimension (since it is a quantity proportional to velocity v). In such a four-dimensional space three dimensions x, y, z determine the distribution of material contents in each universe and antiverse, and the fourth dimension q determines the mutual spatial position of different parallel universes and antiverses.

And since in formulas (4)-(6) the value q , is an additional spatial dimension, it can be stated that in the four-dimensional space of such a hidden Multiverse the parallel universes, continuously drifting relative to each other, touch each other all the time and even often slightly sink into each other, forming a set of bidirectional transition zones or portals, which in Fig. 4 are indicated by single two-sided arrows. On Earth the entrances to the portals [80],[81] are probably at least some of the so-called anomalous zones [82]-[85]. And on Earth they can be on its surface, above and below its surface, on the surface of rivers, lakes, seas, oceans and in their depths. These anomalous zones can have different sizes and

formula has a very important advantage – it introduces into the mathematics of hypercomplex numbers a mathematical operation of raising imaginary numbers to a non-integer power, which was absent until now.

⁷ The term tachyon universe was coined by Isaac Asimov in his short story "Take a Match".

⁸ The term tardion universe was also coined by Isaac Asimov in his short story "Take a Match".

manifest themselves in different ways. And through these portals neighbouring universes can exchange with each other their material contents, including living inhabitants. Therefore, the mass/energy of parallel universes and antiverses in the hidden Multiverse, no matter how they appeared, must have averaged significantly over billions of years of their existence.

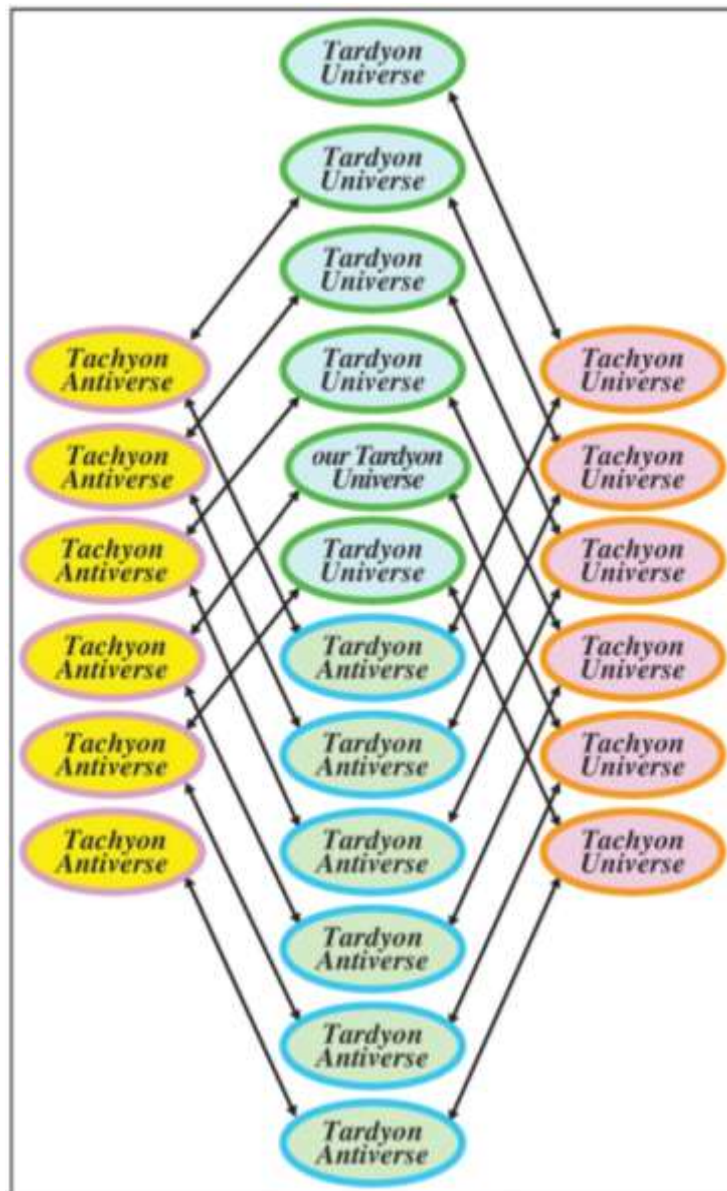


Fig. 4. The proposed open-loop screw structure of the hidden Multiverse, corresponding to the principle of physical reality of complex numbers

Albert Einstein did not exclude such a correction of STR in the future. He wrote: "There is no idea in which I would be sure that it will stand the test of time".

But we have one question left unanswered. As is easy to see, the structure of the hidden Multiverse shown in Fig. 4 has the disadvantage that it does not take into account the existence of the phenomena of dark matter and dark energy, which are not explained in any way. However, they are explained further.

5. Using experimental data obtained by the WMAP and Planck spacecraft

In the twentieth century, two extremely important scientific discoveries were made in astrophysics. One of them, made in 1932-33 by Jan Hendrik Oort [86] and Fritz Zwicky [87], was called dark matter. The other, called dark energy, was made in 1998-1999 by Saul Perlmutter [88], Brian Schmidt [89] and Adam Riess [90], who were awarded the Nobel Prize for it. Emphasizing the significance of these discoveries, Adam Riess wrote: "Humanity stands on the threshold of a new physics of the Universe. Whether we like it or not, we will have to accept it."

According to these discoveries, the mass/energy of dark matter and dark energy is about twenty times greater than the mass/energy of our visible universe, making the problem of explaining them extremely relevance. But these discoveries turned out to be very inexplicable

Indeed, in any range of electromagnetic waves, dark matter and dark energy are invisible, since they do not radiate these waves, do not absorb or reflect. Therefore, they are inaccessible to direct observation. In addition, neither molecules, nor atoms, nor subatomic particles were found in the composition of dark matter and dark energy⁹. Over the past decades, searches for an explanation of the phenomena of dark matter and dark energy were given very much attention and a very large amount of scientific research was done. But the phenomena were not explained. Sol Perlmutter on this occasion noted: "The Universe consists mainly of dark matter and dark energy, but we can't imagine what it is".

And, of course, this situation prompts to think about what is the reason for this result? What is not taken into account? What can be the directions of possible alternative scientific research in accordance with the remark of Albert Einstein: "It is pointless to continue to do the same and expect other results." And the reason for the inexplicability of the phenomena is that the names of these scientific discoveries were understood too literally. Although due to the incomprehensibility of the subject of discoveries, it was impossible to give them more correct names. Nevertheless, the names of these discoveries and what was known about them, as if prompted that the explanation of dark matter and dark energy should most likely be to look somewhere in the microworld of our world, in some of its new structure. Since due to the hypothesis of the Monouniverse, which is in a hundred consequence of the principle of non-exceedance of the speed of light, an explanation of dark matter and dark energy, it would seem, was nowhere else to look for. Therefore, the Nobel Prize laureate Stephen Weinberg suggested: "I hope that it will be possible to open particles of dark matter and that some manifestations of super-symmetry will be discovered. Perhaps, that a superparticle will be discovered, which is just a particle of dark matter. It will be simply remarkable if this happens". They are still looking for this superparticle.

6. Explanation of the phenomena of dark matter and dark energy

Therefore, in the article offered to the attention of readers, an attempt was made to outline the basic principles of a probable alternative explanation of the phenomena of dark matter and dark energy. Moreover, this explanation even implies the existence of another previously unknown phenomenon – the phenomenon of dark space [91], [92].

The structure of the hidden Multiverse can be clarified using data obtained by the WMAP spacecraft, launched in 2001 by the National Aeronautics and Space Administration (NASA) and operating until 2010 [93], as well as the Planck spacecraft, launched by the European Space Agency (ESA) in 2009 and operating until 2013 [94]. According to data obtained by the WMAP spacecraft, the entire universe (in fact, the entire hidden Multiverse) consists of 4.6% baryonic matter, 22.4% dark matter, and 73.0% dark energy. And according to more recent data obtained by the Planck spacecraft, the entire universe (again, in fact, the entire hidden Multiverse) consists of 4.9% baryonic matter, 26.8% dark matter, and 68.3% dark energy. As you can see, these results do not differ much. And this gives rise to confidence that they are correct. But what dark matter and dark energy themselves are has never been explained. It is for this incomprehensibility that these physical entities were called dark.

And since it was proven above in the most indisputable way that in nature there is not a Monoverse, but a hidden Multiverse, then dark matter and dark energy must somehow be present in it. And it is possible that the phenomena of dark matter and dark energy are somehow generated by the entire structure of the hidden Multiverse and are due to the mutual influence of the invisible universes on each other. This alternative assumption we will further consider. Then, if we abandon the condition of seeking an explanation of dark matter and dark energy within the framework of the Monoverse hypothesis and seek it in the hidden Multiverse, then this allows us to quite clearly and convincingly explain the main features of these phenomena that have remained unexplained until now – their invisibility and undetectable corpuscular content:

- dark matter and dark energy are not actually some kind of material physical entities, but merely phenomena (something like a gravitational image) generated by the existence, in addition to our visible tardion universe, of other invisible parallel universes and antiverses of the hidden Multiverse;
- dark matter is a phenomenon generated by the existence of invisible parallel universes and antiverses neighbouring our universe in the hidden Multiverse;
- dark energy is a phenomenon generated by the existence of others, except our visible universe, neighbouring invisible parallel universes and antiverse of the hidden Multiverse;
- and precisely because dark matter and dark energy are just phenomena, they have no material content, and therefore they are invisible in themselves.

⁹ This alone was supposed to suggest that dark matter and dark energy may not be material physical entities, but are only unusual images of something like a gravitational shadow.

That is, there is no unusual material content in dark matter and dark energy in nature. Just as there is no material content in our shadow on a sunny day.

Such explanation of these phenomena also allows to understand the structure of the hidden Multiverse. Indeed, assuming the mass of different invisible parallel universes and antiverses in the hidden Multiverse with a high degree of accuracy due to the presence between them of a large number of portals existing for billions of years is almost the same, it is possible to determine:

- *how many parallel universes and antiverses make up the hidden Multiverse. And according to the above data obtained by the WMAP spacecraft, their number is $100\% / 4.6\% = 21.74$. And according to the data obtained by the Planck spacecraft, their number is $100\% / 4.9\% = 20.41$. Consequently, their real number is presumably equal to 20...22 universes and antiverses. I.e. besides our visible universe there are 19 ... 21 invisible universes and antiverses.*

- *how many parallel universes and antiverses are neighbouring our universe and give rise to the phenomenon of dark matter. According to the data obtained by the WMAP spacecraft, their number is $22.4\% / 4.6\% = 4.87$. And according to the data obtained by the Planck spacecraft, their number is $26.8\% / 4.9\% = 5.47$. Consequently, their real number is most likely equal to 5...6 parallel universes and antiverses.*

- *how many parallel universes and antiverses give rise to the phenomenon of dark energy. And according to the data obtained by the WMAP spacecraft, their number is $73.0\% / 4.6\% = 15.87$. And according to the data obtained by the Planck spacecraft, their number is $68.3\% / 4.9\% = 13.94$. Consequently, their real number, presumably, is equal to 14...16 parallel universes and antiverses.*

7. Structure of the hidden Multiverse

And then the discrepancy of the obtained results of these calculations with the structure of the hidden Multiverse given above in Fig. 4 is immediately striking. which cannot be explained by inaccurate measurements of WMAP and Planck spacecraft, because the difference between the results of calculations and experimental data is too great. Neighbouring with our universe other parallel universes appeared not two, but five or six. But such a number of them does not fit into the structure shown in Fig. 4.

Moreover, the above calculations allowed us to determine only statistical average datas. And since there are more than two hundred thousand anomalous zones and, consequently, portals on the Earth, it is not excluded that some small number of portals on the Earth can connect it with a larger number of neighbouring universes. Therefore, the astro-geophysical studies of portals mentioned below will presumably provide very valuable information about other universes of the hidden Multiverse.

Then it is logical to assume that the previous reasoning contained some mistake. And this error consists in the fact that earlier for simplicity we assumed in the hidden Multiverse the existence of only one additional dimension and, consequently, its correspondence to physically real complex numbers containing only one imaginary unit. And for six other parallel universes –three tachyon universes and three tachyon antiverses – to neighbour our universe it is necessary to have three additional dimensions q, r, s , by which their position in space will be determined. Consequently, the space of such a hidden Multiverse will be six-dimensional (see Fig. 5). And its structure will correspond to quaternions $\sigma + i_1\omega + i_2\omega + i_3\omega$, i.e. hypercomplex numbers [95], containing just three imaginary units i_1, i_2, i_3 , which are related to each other by relations

$$i_1^2 = i_2^2 = i_3^2 = -1 \quad (7)$$

$$i_1 i_2 i_3 = i_2 i_3 i_1 = i_3 i_1 i_2 = -1 \quad (8)$$

$$i_1 i_3 i_2 = i_2 i_1 i_3 = i_3 i_2 i_1 = 1 \quad (9)$$

In such a quaternionic structure of the hidden Multiverse, the distribution of material contents in each three-dimensional parallel universe and antiverse will be determined by some function $f_{qrs}(x,y,z)$, and the values i_1q, i_2r, i_3s are the coordinates of these universes and antiverses (see Fig. 5). I.e. the structure of the hidden Multiverse is described by the formula $f_{qrs}(x,y,z) + i_1q + i_2r + i_3s$. This is what Lisa Randall meant: "Perhaps we live in a three-dimensional pocket of multidimensional space".

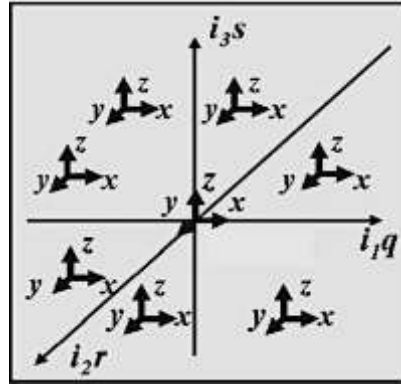


Fig. 5. Six-dimensional space of the hidden Multiverse, in which q, r, s – are coordinates of invisible parallel universes and antiverse, and x, y, z – are coordinates of material contents in each such parallel universe and antiverse

Therefore relativistic formulas (4)-(6) should be once again corrected as follows

$$m(q, r, s) = \frac{m_0 i_1^q i_2^r i_3^s}{\sqrt{1 - [\frac{v}{c} - (q + r + s)]^2}} \quad (10)$$

$$\Delta t(q, r, s) = \Delta t_0 i_1^q i_2^r i_3^s \sqrt{1 - [\frac{v}{c} - (q + r + s)]^2} \quad (11)$$

$$l(q, r, s) = l_0 i_1^q i_2^r i_3^s \sqrt{1 - [\frac{v}{c} - (q + r + s)]^2} \quad (12)$$

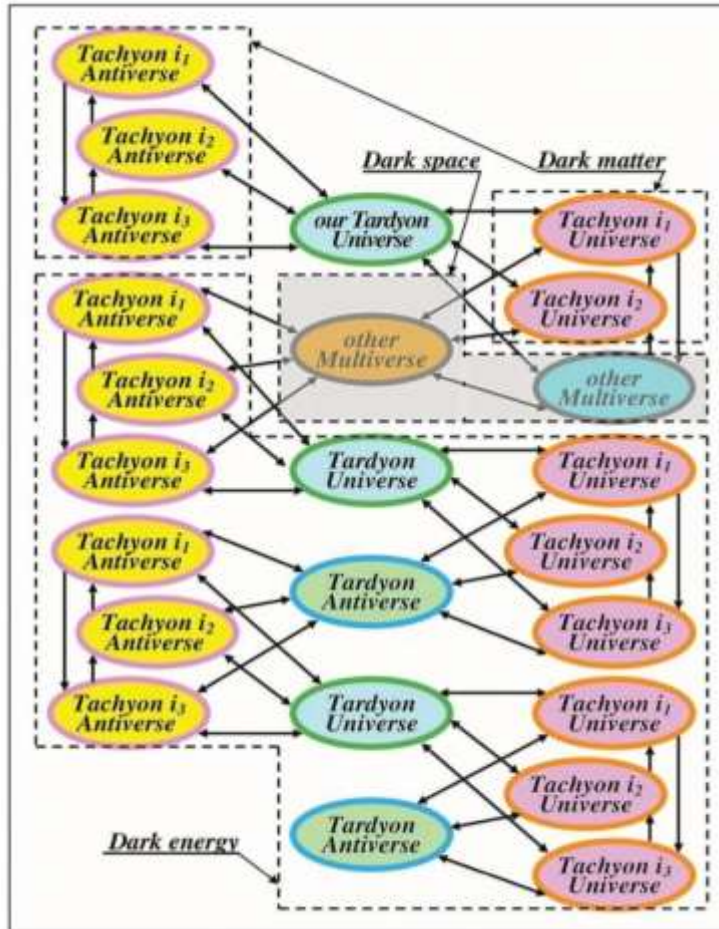


Fig. 6. The proposed open-loop screw structure of the hidden Multiverse, corresponding to the principle of physical reality of hypercomplex numbers

where $q(v) = [v_q/c]$ is the "floor" function of discrete mathematics from the argument v/c ,

which is the fourth spatial dimension;

$r(v) = [v_r/c]$ is the "floor" function of discrete mathematics from the argument v/c , which is the fifth spatial dimension;

$s(v) = [v_s/c]$ is the "floor" function of discrete mathematics from the argument v/c , which is the sixth spatial dimension;

v_q, v_r, v_s are projections of velocity vector v on orthogonal coordinates q, r, s .

Therefore from formulas (10)-(12) follows a very important conclusion - the velocity v mentioned in Newton's first law, which serves in the uncorrected version of STR as the fourth spatial dimension, turns out to be not scalar, but vector quantity, determining in orthogonal coordinates i_1q, i_2r, i_3s the position in the cosmic space of universes and antiverse of the hidden Multiverse.

And the information about the screw structure of such hidden Multiverse is contained in formulas (7)-(9). It follows from them that it is possible to move to the tardion antiverse from the tardion universe and to the tardion universe from the tardion antiverse in different, but not arbitrary ways, but only in such a way that the value i_1^q, i_2^r, i_3^s will successively take the values $+1, +i_1 \oplus i_2 \oplus i_3, -1, -i_1 \oplus i_2 \oplus i_3, +1, \dots$ etc., where $\oplus$ is the symbol of the logical operation of discrete mathematics 'exclusive OR'. In this case, different trajectories of travelling from one universe (or antiverse) to another can differ only by replacing one tachyon universe i_1, i_2, i_3 by another and one tachyon antiverse i_1, i_2, i_3 by another. Hence, the tachyon universes i_1, i_2, i_3 in the hidden Multiverse are placed parallel to each other. The tachyonic antiverse i_1, i_2, i_3 are also placed parallel to each other for the same reasons. And so in the hidden Multiverse parallel universes and antiverse must alternate in the following sequence - 'tardion universe', 'one of the tachyon universes', 'tardion antiverse', 'one of the tachyon antiverse', 'tardion universe', 'one of the tachyon universes', etc. An example of the quaternionic structure of such a hidden Multiverse is given in Fig. 6.

Thus, one difference of the structure shown in Fig. 6 structure from the structure shown in Fig. 4 is the presence in it of several different parallel included tachyon universes and antiverses corresponding to three imaginary units i_1, i_2, i_3 . Another difference of the Multiverse structure, due to formulas (7)-(9), is the presence in this structure of the Multiverse not only of bidirectional portals corresponding to formula (7) and denoted by bilateral arrows, but also of unidirectional portals¹⁰ corresponding to formulas (8), (9) and marked by unilateral arrows.

8. How to experimentally prove the existence of portals?

The above information is quite convincing. But only if the portals actually exist. And only experiments can give full confidence in this. So it's time to describe such an experiment. And the proposal to conduct an inexpensive but very convincing experiment has already been published [96]-[113].

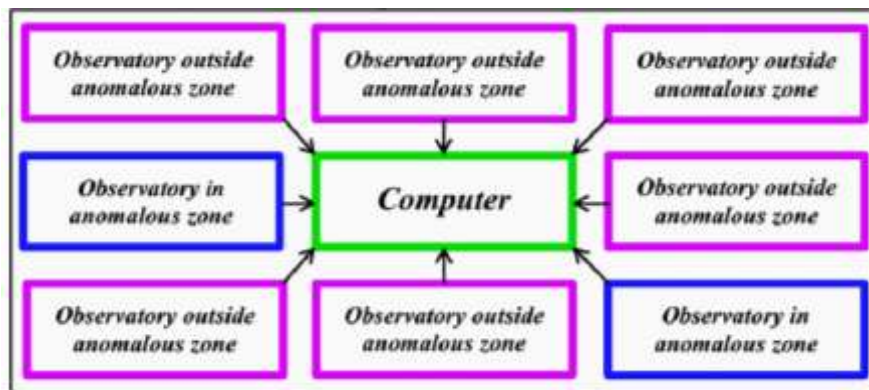


Fig. 7. Scheme of an astronomical experiment to detect invisible universes

As can be seen in Fig. 6, all portals begin and end at different astronomical objects. Consequently, on the starry sky at the entrance and exit of portals will always be observed completely different constellations. Therefore, when travelling through the portals, the map of the starry sky will gradually change, eventually gradually replacing some constellations with others. And the fact that constellations,

¹⁰ Due to what circumstances in such portals movement is possible only in one direction - from entrance to exit - it is difficult for us, living in a space in which movement is possible in any direction, even to imagine. And the processes that make such movement possible in nature are yet to be understood. But they are more dangerous than bidirectional portals for visitors who have entered such unidirectional portals, because it is impossible to return to one's own universe from them. Though in the underground with unidirectional movement on escalators we do meet them. But the underground is not nature.

never observed outside the portals, will be observed in the portals will allow to detect the portals. And not only portals, but also neighbouring universes¹¹, which will allow the structure of our hidden universe to be clarified. And even to determine the possible presence of neighbouring universes and antiverse, which are not included in the hidden Multiverse. But forming together with the hidden Multiverse the Hyperuniverse, to which corresponds the phenomenon of dark space.

And the entrances to the portals are the so-called anomalous zones, of which there are many on our planet - more than two hundred thousand. And in some of these anomalous zones, observatories have already been located. Like, for example, the Main Astronomical Observatory of the National Academy of Sciences of Ukraine, which is located in the Goloseevsky forest just 12 km from the center of the capital of Ukraine, Kiev.

But people avoid going into the portals. And rightly so, because portals are labyrinths and they're invisible. So if you accidentally once you've entered a portal, it's almost impossible to get out. But it's possible to create equipment for orientation in portals is possible. It's also possible to use unmanned remotely piloted vehicles using unmanned, remote-controlled robotic vehicles. You just have to want to. It is even possible not to go far into the portals, but to limit ourselves to the use of anomalous zones. Although in anomalous zones, i.e. at the very edge of the portals, the change in the appearance of the constellations we know is very small, still can be detected by comparing on the computer (Fig. 7) observations of the same areas of the starry sky by different observatories located both in the anomalous zones and outside the anomalous zones in the same region.

And if these differences are too small, the telescope will have to be moved deeper into the portal. After all, Sir Arthur Stanley Eddington [114] was able to carry out his famous experiment, which confirmed the predicted by the general theory of relativity deviation of light rays in the gravitational field of the Sun back in 1919, to move his telescope much further – from England to the island of Principe in the Atlantic Ocean.

9. The relevance of astro-geophysical researches of portals needed to create a time machine

Thus, the above allows us to consider it proven that:

- the hidden Multiverse really physically exists;
- the hidden Multiverse has a quaternionic structure and contains, in addition to our visible tardionic universe, about twenty more mutually invisible tardionic and tachyon universes and antiverse, connected with each other by bidirectional and unidirectional portals;
- the tardion and tachyon universes contain matter, space and time, and the tardion and tachyon antiverse contains anti-matter, anti-space and anti-time;
- travelling through the hidden Multiverse in space is accompanied by time travel.

It follows that in the hidden Multiverse it is possible to create different time-travelling routes in the hidden Multiverse by setting the corresponding routes of travelling through this Multiverse in space [115]-[123]. But we will not do it, because the research of such routes in the hidden Multiverse would be too expensive. And it is not necessary, as for creation of time machines we need only information which can be received by geophysical researches of portals [124]-[141]. And not even the research of portals on full depth, but only the research of their relatively small entrance areas, because, most likely, their geophysical parameters will be the same along the entire length of the portals from the entrance to the exit.

10. Conclusion

In the article examples of practically useful and realisable on the Earth time travels with the use of time zones are given.

In the article it is also proved that the version of STO studied in all physics textbooks is incorrect because:

- the relativistic formulas obtained in it are incorrect;
- they are incorrectly explained using the incorrect postulate about the non-exceeding of the speed of light;
- from incorrect relativistic formulas wrong conclusions about physical unreality of imaginary numbers and about existence of our only visible universe in nature are made.

Therefore the corrected version of STO was created, in which;

- the principle of physical reality of imaginary numbers is experimentally proved and theoretically explained, by which the postulate about non-exceeding of the speed of light is refuted;

¹¹ In the same way, we can see the adjacent invisible room (or at least the edge of it, to make sure it exists) next to our visible room, which we are currently in, only if we go into the corridor between these rooms.

- the corrected relativistic formulas explained with the use of the principle of physical reality of imaginary numbers are obtained;
- from the corrected relativistic formulas the conclusion about existence in Nature of quaternionic structure of the hidden Multiverse, containing besides our visible Universe about twenty mutually invisible tardionic and tachyon universes and antiverses, connected with each other by bidirectional and unidirectional portals, was made.

The article describes experiments that allow by geophysical researches to experimentally prove the existence of portals. And the knowledge obtained in such geophysical research will allow the creation of time machines.

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Political sciences

TRANSFORMATION OF SECURITY DIPLOMACY IN EUROPE 1945 – 2024

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ТРАНСФОРМАЦІЯ БЕЗПЕКОВОЇ ДИПЛОМАТІЇ В ЄВРОПІ 1945 – 2024

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Abstract

We explore how security diplomacy is undergoing constant evolution in the multipolar dimension of international relations. First, we illustrate that in the absence of concepts of security diplomacy efforts, world security may be under serious threat in real geopolitical trends. Next, we consider the historical context after World War II and the period of transformation in relations between Eastern and Western Europe. We present the general changes in diplomacy after the Cold War that influenced the evolution of European relations, which have a direct impact on modern global security. Based on the impact of European integration, we illustrate changes in security diplomacy within the framework of stabilizing the world order. Based on cases of contemporary challenges, we examine how global security is evolving into new perspectives for the development of diplomatic approaches in the context of globalization and international cooperation.

Анотація

Ми досліджуємо як безпекова дипломатія зазнає постійної еволюції в багатополарному вимірі міжнародних відносин. Спочатку ми ілюструємо, що за відсутності концепцій зусиль безпекової дипломатії світова безпека може опинитися під серйозною загрозою в реальних геополітичних тенденціях. Далі ми розглядаємо історичний контекст після Другої світової війни та період трансформації у відносинах між Східною та Західною Європою. Ми представляємо загальні зміни в дипломатії після Холодної війни, які вплинули на еволюцію європейських відносин, що мають прямий вплив на сучасну глобальну безпеку. Спираючись на вплив європейської інтеграції, ми ілюструємо зміни в безпековій дипломатії в рамках стабілізації світового порядку. На прикладі випадків сучасних викликів ми розглядаємо, як глобальна безпека розвивається в нових перспективах розвитку дипломатичних підходів у контексті глобалізації та міжнародного співробітництва.

Keywords: *diplomacy, peace, agreements, strategies, organizations, transformation.*

Ключові слова: *дипломатія, мир, угоди, стратегії, організації, трансформація.*

Вступ

Еволюція безпекової дипломатії є природним і надзвичайно важливим природним фактором, здатність якого якісно трансформуватися та адаптуватись до світових тенденцій, гарантує мир і стабільність у всьому світі. Із тим самим розрахунком, стратегії покращення мирної інтеграції ставлять питання європейської дипломатії на одне із перших місць у сучасній системі міжнародних відносин. У цій статті розглядаються загальна історична та практична основа реорганізації трансформації дипломатичних внесків в період між 1945-2024 років, які можуть слугувати основою для загального вивчення структури міжнародної безпеки на європейському континенті. Що стосується передумов, за яких міжнародна безпека набула найважливішого

значення, то мир завжди був онтологічно обумовленим фактором стабільного співіснування на всіх рівнях людства, що є вкрай важливим у будь-який час. Історіографія післявоєнного періоду починаючи із 1945-х до 1990-х року зазнала принципіальних змін в межах якої встановлення нових систем міжнародної співпраці та порядку було невід'ємним фактором. Ці зміни відображалися не лише в міжурядових відносинах, але й у способах, якими держави взаємодіяли на міжнародній арені. Протягом цього періоду країни Європи змушені були адаптувати свої стратегії, щоб відповідати новим викликам, що виникають у глобальному контексті. Договори, альянси та правила, що виникли після Другої світової війни, істотно вплинули на концепцію відновлення дипломатичних зв'язків між державами в намаганні пошуку компромісу та встановленню сильних міжнародних організацій, що б гарантували та регулювали мир як основу світового правопорядку. Тенденція міцних та організацій зростала з кожним десятиліттям європейської історії, в якій абсолютно кожна держава намагалась балансувати національні та міжнародні інтереси. Зрештою, двополюсна система, що виникла на основі цього періоду відіграла вирішальну роль у визначенні характеру безпекової дипломатії на десятиліття вперед. У цій системі основна увага була зосереджена на стримуванні та протистоянні між СРСР і Заходом, в надії встановити власні правила гри, які відповідали б інтересам однієї із сторін, протиставляючи національні інтереси загальному благу.

Головні трансформації в міжнародній дипломатії після завершення Холодної війни ґрунтувалися на істотних аспектах, а також на нових викликах і можливостях для багатьох країн світу, які прагнули визначити своє місце в розширеному глобальному правовому середовищі, що перебувало в мінливому стані глобальних змін, коригуючи власні стратегії та підходи відповідно до нових умов і реалій. У статті розглянуті ключові кризи та ядерні загрози, які стали рішучою силою для створення ядерної дипломатії в контексті політики стримування в Європі. Завершення Холодної війни призвело до важливих і значних глибоких змін у безпековій дипломатії, які мали далекосяжні наслідки. Ці зміни, зокрема, сприяли масштабному розширенню як Європейського Союзу, так і НАТО, що суттєво вплинуло не лише на нові політичні реалії, але й на міжнародну стабільність у багатьох регіонах світу. Це розширення стало важливим фактором у формуванні нової архітектури безпеки в постхолодній системі, впливаючи на співпрацю між державами та створюючи нові виклики, які потребували ефективного врегулювання й адаптації політики.

Вплив євроінтеграції на безпекову дипломатію після наслідків Холодної війни значно трансформував політичні відносини між європейськими державами, оскільки сприяв інтеграції країн Центрально-Східної Європи до європейських структур і забезпечив нові можливості для співпраці, особливо в таких сферах, як економіка, безпека та культура. Це, в свою чергу, дозволило країнам регіону не лише відновити свої економіки, але й зміцнити демократичні інституції. Цей процес став можливим завдяки спільним зусиллям європейських країн, які прагнули до інтеграції та стабільності в регіоні. Важливим аспектом цієї еволюції стало підписання численних організаційних та комплексних міжнародних угод, спрямованих на зміцнення співробітництва між державами. У статті ми розглядаємо як євроінтеграційні процеси сприяли поглибленню співпраці між європейськими країнами в галузі безпеки. Ці процеси сприяли не лише розвитку економічних зв'язків, але й зміцненню політичної стабільності в регіоні, що стало важливим фактором для підтримки миру та безпеки в Європі через введення нових стандартів і політик для забезпечення сильної регіональної безпеки.

У статті ми також досліджуємо як сучасні виклики та геополітичні можливості, які виникли до 2024 року, вимагали термінового перегляду традиційних дипломатичних практик відповідно до нових реалій глобального світу. Стаття визначає, що ці зміни істотно впливають на запропоновані стратегії міжнародних відносин. Особливе значення має аналіз того, як суттєві трансформації в міжнародному середовищі конфлікту в Україні позначаються на підходах європейських країн до реалізації зовнішньої політики, що, в свою чергу, визначає їх зовнішньоекономічні та інноваційні стратегічні комунікації. До розгляду пропонується обґрунтування нових загроз, такі як кіберзагрози, тероризм та гібридні війни, які, як визначено, вимагають швидкої адаптації дипломатичних стратегій від оборонних організацій та власне самих держав. Ці нові виклики зумовлюють необхідність перегляду традиційних підходів держав до міжнародних відносин, підкреслюючи важливість мультидисциплінарного підходу в дипломатії та розуміння нової геополітичної реальності, що включає співпрацю з неурядовими організаціями та якісними міжнародними установами. Щоб отримати уявлення про перспективи розвитку безпекової дипломатії в контексті глобалізації та міжнародної співпраці

розглядаються новітні ефективні моделі та ініціативи, які сприяють дипломатів кожної із країн до міцних спільних домовленостей.

Як висновок, у статті ми узагальнюємо згадані ідеї та розгляд історіографії дипломатії зазначеного періоду на основі тенденцій відповідних до сучасних викликів. Ми також визначаємо важливість розуміння історико-політичного контексту для розуміння безпекових основ дипломатії в Європі. Підсумовуючи ми доводимо, що зміни, які відбулися після Другої світової війни та її наслідки для зовнішньополітичних стратегій країн залежали від багатьох факторів, включаючи економічні, соціальні та культурні аспекти. Зокрема, враховано зміну геополітичної ситуації, яка призвела до нових альянсів і конфліктів, а також адаптацію дипломатичних підходів до глобальних викликів. Нами також доведено, що нові виклики вимагають нових та швидких підходів до встановлення ефективних стратегій, які можуть гарантувати мир та стабільність на континенті.

У розвитку Ялтинсько-Потсдамської системи, яка нарощувала свій вплив для двополюсної системи.

1. Післявоєнна дипломатична реорганізація 1940-1950х років

Після завершення Другої світової війни світ увійшов у нову фазу міжнародного порядку, що регулювався так званою Ялтинсько-Потсдамською системою міжнародних відносин. Ця система не лише переосмислила геополітичний ландшафт Європи, але й заклала основи для розвитку моделей безпеки, які вплинули на подальшу динаміку Холодної війни. Наслідки цієї системи врешті-решт позначилися на балансі сил та характері дипломатії протягом другої половини XX століття. Фактично, Ялтинсько-Потсдамська угода встановила біполярну архітектуру безпеки, яка в основному контролювалася Сполученими Штатами та Радянським Союзом. Кожна з наддержав визначила свою власну сферу впливу, запроваджуючи специфічні дипломатичні підходи щодо союзників та опонентів у відповідних регіонах.

Ялтинсько-Потсдамська система міжнародних відносин для дипломатичного розгляду стала основою для визначення нових кордонів у Європі, розділивши континент на сфери впливу між Сходом і Заходом. Це призвело до формування нового порядку на двох протилежних блоках, що, в свою чергу, стимулювало розвиток безпекових альянсів, серед яких був Північноатлантичний альянс (НАТО). Основоположкою ідеєю НАТО стало положення про колективну оборону, закріплене в статті 5 Вашингтонського договору, передбачало, що напад на одну з держав-учасниць сприйматиметься як напад на всі. Доктрина НАТО, яка була продектована голосом всіх членів організації мала на меті дві основні стратегічні цілі: стримування і оборона [1. с. 42]. Дипломатична консолідація всіх учасників процесу гарантувала врахування інтересів кожної держави, що зумовлювало та підтверджувало основні наративи нової на той момент безпекової організації. Це стало основою для формування безпечного середовища в умовах Холодної війни та дозволило країнам-учасникам спільно вирішувати загрози, що прийшли з боку майбутнього Варшавського блоку. Загалом, Західна Європа, яка була об'єднана під егідою НАТО, прагнула не лише здійснювати безпекові ініціативи, але й підтримувати економічне відновлення через План Маршалла, який мав на меті стримати радянський вплив шляхом економічної стабілізації. Цей план не лише сприяв відновленню інфраструктури, але й сприяв створенню нових економічних зв'язків між західноєвропейськими державами, що зменшувало ризик конфліктів та посилювало стабільність у регіоні. Це, в свою чергу, стало основою для формування нових союзів, таких як Європейська економічна спільнота, що сприяло інтеграції та співпраці серед країн регіону.

Німеччина відіграючи роль гарантної нової міжнародної системи у розумінні поділу її територій на чотири сфери впливу між США, СРСР, Великою Британією та Францією для забезпечення дипломатичної стабільності стало не лише символом пошуку найлегших шляхів встановлення миру, а й мети встановити дипломатичний мирний плацдарм. Цей поділ, що відбувався після закінчення Другої світової війни, започаткував етапи формування безпекових альянсів, які мали на меті стримування потенційних конфліктів і запобігання новим загрозам. Важливу роль у цьому процесі відіграли НАТО та Варшавський договір, які в свою чергу визначали стратегії та політики обох блоків. Цей складний процес поділу не лише формувал нові кордони, а й створював глибокі історичні наративи, які в подальшому вплинули на соціальну та політичну структуру Німеччини. Західна Німеччина, яка стала символом стрімкого економічного зростання й демократичних цінностей, яскраво контрастувала з Східною Німеччиною, що переживала численні політичні репресії й економічну невдачу під жорстким комуністичним режимом. Ці різні наративи не лише стосувалися внутрішньої політики, але й визначали зовнішню політику

Німеччини, де вона стала важливим гравцем на міжнародній арені, змушуючи інші країни адаптувати свої стратегії та підходи до нових реалій, які виникли внаслідок цих кардинальних змін. Німеччина виявилася в центрі глобальних безпекових і економічних дискусій, його роль ставала все помітнішою у світі, що швидко змінювався. Це зумовлено не лише геополітичними змінами, але й зростанням економічної потужності Німеччини, яка стала ключовим гравцем у формуванні нових безпекових альянсів.

Висновок із наведеного тексту свідчить про те, що після Другої світової війни світ зазнав суттєвих змін у міжнародних відносинах, що обумовлено виникненням Ялтинсько-Потсдамської системи. Ця система стала основою для формування біполярного світу, в якому Сполучені Штати та Радянський Союз контролювали свої сфери впливу, що значно вплинуло на дипломатію й баланс сил протягом другої половини XX століття. У рамках цієї системи розвинулися нові моделі безпеки, зокрема, створення НАТО, яке закріпило концепцію колективної оборони. Також відзначено, що План Маршалла відіграв важливу роль у відновленні економіки Західної Європи і сприяв інтеграції між державами регіону. Поділ Німеччини на Східну та Західну, що став результатом нової міжнародної системи, призвів до контрастних соціально-політичних реалій, які мали глибокий вплив на зовнішню політику та міжнародну роль Німеччини. Таким чином, ця епоха стала визначальною для формування нових безпекових альянсів, стратегій та політик, що залишили свій слід на історії Європи та світу в цілому. Простими словами, період післявоєнної реорганізації поставав як етап визначення нових правил гри в європейських міжнародних відносинах, котрий викликав потребу в орієнтації на колективні оборонні механізми.

2. Період Холодної війни (1950-1990-і роки)

На противагу, Східна Європа під керівництвом Радянського Союзу намагалася закріпити позиції соціалістичних режимів, що посилювало конкуренцію та потенційні конфлікти в регіоні. У відповідь на це, Варшавський договір створений у 1955 році забезпечив військову одиницність радянських сателітів, підкреслюючи розподіл впливу між двома величезними політичними системами, а саме капіталізмом та соціалізмом. Цей період характеризується чітким поділом Європи на два основні блоки, що у свою чергу активізувало форму стримування конфліктів. Цей поділ не лише змінював геополітичну карту Європи, але й формував безпекову дипломатію, яка надалі стала визначальним фактором у міжнародних переговорах протягом Холодної війни. Розвиток безпекових альянсів суттєво вплинув на формування стратегій стримування, які не лише регулювали підходи держав до військової політики, але й формували суспільні уявлення про загрози та безпеку. У цьому контексті європейська безпека стала не лише питанням військової раціональності, а й політичного діалогу, що зумовило необхідність у нових механізмах забезпечення миру на континенті.

Важливо зазначити, що переміщення кордонів впливу та зміна військових стратегій з обох сторін супроводжувалась постійними політичними тисками та кризами: від Берлінської блокади до подальших криз у Чехословаччині та Угорщині. У даних подіях йшлося не лише про приховані військові маневри, а й про ідеологічні битви, що відображали боротьбу за серця і розуми європейських народів. Берлінська криза 1948-1949 років та її вплив на міжнародну систему безпеки був яскравим прикладом зростання напруженості між Сходом і Заходом, що суттєво вплинуло на формування нових стратегій безпеки. Цей етап історії продемонстрував, якою важливою була роль безпекових альянсів, таких як НАТО, у забезпеченні стабільності в Європі та демонстрації рішучого курсу на створення західнонімецької держави [2]. Таким чином, відзначаючи поділ континенту, можна стверджувати, що безпекова дипломатія почала набирати обертів, оскільки країни прагнули знайти спосіб завадити ескалації конфліктів і підтримати мир, однак не завжди це призводило до кінцевого вирішення криз. Безпекові альянси, у цьому контексті, не просто об'єднували країни, але й формували нову політичну реальність, що стала основою для подальшого розвитку дипломатії в Європі. Таким чином, поділ Європи не лише визначив географічні та стратегічні лінії, але й став каталізатором для багатоглибких трансформацій, які продовжують впливати на європейську політику до сьогодні.

Тривав цей період з 1950 до 1990-х років, який ознайменювався інтенсивним протистоянням між двома наддержавами - Сполученими Штатами Америки та Радянським Союзом, в якому ядерна дипломатія стала не основним, але точно ключовим елементом безпекових стратегій в Європі на той період. Концепція Угорської кризи 1956 року, яка стала ключовим моментом, суттєво вплинула на розвиток безпекової дипломатії в Європі того періоду. Напруженість, яка виникла внаслідок народного повстання проти радянського режиму, стала каталізатором нових

стратегій, що включали як формування союзів, так і дипломатичні ініціативи, спрямовані на забезпечення стабільності в регіоні. Західні країни, спостерігаючи за подіями в Угорщині, усвідомили необхідність зміцнення колективної безпеки в рамках НАТО, адже угорські події продемонстрували вразливість країн-сателітів СРСР та їхню потенційну здатність до опору. У цьому контексті, поки бажання адміністрації США прокласти шлях до звільнення Центрально-Східної Європи з радянського впливу підвищувало дипломатичну активність, стримуючі засоби залишалися в руках реальної сили, що була готова використовувати військові опції для підтримки режимів, які сприяли їхнім інтересам. У результаті, угорська криза вплинула на формування нового підходу до стратегій зовнішньої політики, в якому важливу роль відігравали стратегії дезінформації та контроль над комунікаціями. Результати кризових подій підкреслили важливість не лише вивчення фізичних загроз, але й психологічних аспектів дипломатії, таких як вплив пропаганди на маси. Дипломатичні зусилля стали не лише пошуками консенсусу, але також і активною боротьбою за уми та серця людей, що в кінцевому результаті змінило моральні та етичні підвалини зовнішньої політики держав, які прагнули зберегти свої національні інтереси в умовах нестабільності. Варто додати, що угорська криза підштовхнула до переосмислення ролі міжнародних організацій у забезпеченні безпеки. ООН, хоча і не змогла вирішити конфлікт, проте стала свідком еволюції ідей колективної відповідальності за міжнародний порядок. Таким чином, події в Угорщині відкрили нові горизонти для обговорення принципів міжнародної безпеки, закріпивши незворотні зміни в підходах до вирішення конфліктів в Європі, які залишатимуться актуальними протягом наступних десятиліть.

На фоні інших загроз виникали нові виклики міжнародної системи у вигляді Берлінської стіни, що була зведена у 1961 році, яка стала символом розподілу Європи на дві протилежні системи, як вже зазначалося - капіталістичну та соціалістичну. Це зведення наочно демонструвало наслідки геополітичної боротьби. У цих критичних ситуаціях дипломатичні стратегії виявилися надто важливими для контролю ескалації конфліктів. Встановлення "гарячих ліній" між Вашингтоном і Москвою стало важливим кроком у запобіганні непорозумінням, що могли призвести до катастрофічних наслідків. Будівництво Берлінської стіни дозволило визначити дипломатичні стратегії країн НАТО та Варшавського договору, які були спрямовані на підтримку балансу сил, запобігання прямому військовому конфлікту та впливу на політичну ситуацію в Німеччині та Східній Європі. Сполучені Штати та Західна Німеччина прагнули деескалації напруги, а також підтримування політичного впливу в Західному Берліні.

Акценти подальшої трансформації дипломатичного устрою, які були спрямовані на ядерне стримування, що базувалося на доктрині взаємного гарантованого знищення, що згодом відіграло визначну роль у забезпеченні відносної стабільності на континенті. Ця концепція покладала відповідальність за можливість застосування ядерної зброї на обидві сторони конфлікту, що утримувало їх від відкритого військового зіткнення. У рамках цієї дипломатії, основними гравцями стали не лише військові та політичні лідери, а й стратегічні аналітики, які розробляли сценарії можливих конфліктів, що спиралися на технологічні досягнення в галузі ракетобудування та ядерної фізики. Таким став новий період в дипломатичній історії, який отримав назву Холодна війна.

Карибська криза 1962 року, що загострила напруженість між США та СРСР, змусила світ поставити під сумнів можливість ядерної війни. Конфлікт, що виник через розміщення радянських ядерних ракет на Кубі, призвів до безпосереднього військового зіткнення між двома наддержавами, ставлячи людство на межу третьої світової війни. Наслідки цього етапу не лише перетворили стосунки між США і СРСР, але й вплинули на глобальну безпеку, політичну архітектуру та механізми міжнародної дипломатії. У цьому контексті, однією з найбільш суттєвих характеристик ядерного стримування було формування стратегічного балансування, яке діяло як запобіжник від прямого військового конфлікту.

По-перше, Карибська криза підкреслила важливість комунікаційних каналів у міжнародній дипломатії. Відзначаючи критичні недоліки в механізмах зв'язку між великими державами, що призвели до помилкових оцінок і підвищення військової напруги, криза спонукала створення як зазначалося «гарячої лінії» між Вашингтоном та Москвою. Це стало важливим кроком у напрямку зменшення ризику ядерного збройового конфлікту, ставши еталоном для подальшого розвитку дипломатичних інструментів.

По-друге, вплив Карибської кризи також окреслив нову еру в міжнародних відносинах, де концепція «взаємного запобігання» (mutual assured destruction) стала домінуючою в осмисленні стратегічної стабільності [3]. Ця концепція вимагала від держав уникати відкритих конфліктів,

адже такі дії могли призвести до непоправних наслідків для всього людства. Також, криза спонукала до зростання активності міжнародних організацій, таких як ООН, та ініціювала численні переговори щодо контролю над озброєннями. Ці зміни сприяли формуванню нової системи безпекових гарантій, що спиралася на багатосторонні договірні механізми, спрямовані на обмеження розповсюдження ядерної зброї та зменшення загалом військових конфліктів у світі [3]. Таким чином, Карибська криза стала важливим каталізатором для подальшої трансформації глобальної політики безпеки, змістивши фокус на співпрацю та дипломатію як основні інструменти в умовах ядерного століття.

У Європі, ядерна дипломатія найяскравіше проявилася через сприяння альянсу НАТО, що став архетипом колективного стримування та безпеки. У рамках цього альянсу, країни-учасниці здійснили реалізацію політики ядерного стримування, яка включала в себе складну загрозу відповіді у випадку ядерного нападу. Головною стратегією було забезпечуючи захист та спільну безпеку серед своїх членів, що було надзвичайно важливо для запобігання можливим конфліктам. Зокрема, Північноатлантичний альянс створив умови для тіснішої співпраці в питаннях безпеки, що посилило довіру між країнами і зменшило ризики ескалації криз. Активна коаліційна дипломатія, застосована під час зближення держав в рамках ЄС і Варшавського договору, додатково ілюструє, що динаміка міжнародних відносин окрім відвертих конфліктів могла бути збалансована через економічну інтеграцію та культурні ініціативи. Завдяки цьому виникали нові платформи для спілкування та співпраці, зокрема у галузі науки та технологій, навіть коли ідеологічні розбіжності залишалися дуже вираженими. Так, стратегія неоднолінійного підходу до міжнародної політики, яка враховувала як військові, так і невоєнні засоби, підкреслює комплексність та багатогранність дипломатичних зусиль, спрямаючи їх у бік уникнення глобальних конфліктів, в той час як запобігання військовим зіткненням перепліталось з ринковою та культурною конкуренцією.

Нові виклики як-от окупація Чехословаччини військами Варшавського договору в 1968 році, стала важливим етапом у формуванні нової геополітичної реальності де зростання напруженості та конфліктів вимагали від безпекового альянсу НАТО негайної дипломатичної та політичної реакції на загрози, що виникали внаслідок радянської експансії. Відповідь НАТО на події, що мали місце в Чехословаччині, відображала не лише внутрішній опір союзників, а й потребу в адаптації до нових геополітичних реалій. Запобігання радянським задумам, вимагало як підвищеної військової готовності й стійкості, так і продуманої дипломатії, здатної справлятися з новими викликами. Ця ситуація стала рушійною силою для розвитку нових моделей безпеки в регіоні, акцентуючи важливість співпраці різних акторів, що виходили за межі державного рівня, до міжнародних організацій, таких як ООН та регіональних інституцій. Таким чином, події в Чехословаччині стали не лише серйозним випробуванням для НАТО, але й потужним каталізатором для формування нових підходів до міжнародної безпеки, спрямованих на профілактику подібних криз і підтримку стабільності в регіоні в майбутньому.

Загалом, дипломатичні стратегії Холодної війни включали концепцію стримування, що полягала в запобіганні розширенню комуністичного впливу, та концепцію дестабілізації супротивника, що також включала підривні заходи всередині країн, які сприймалися як загроза. У контексті детенту, який поставав у середині 1970-х, акцент зроблено на зниженні напруженості між суперниками через угоди про контроль над озброєннями, як-от Договір про протиракетну оборону (ABM) та стратегічні угоди про обмеження наступальних озброєнь (SALT). Зазначені дипломатичні концепції та їх практичне застосування мали серйозний вплив на політику того часу. У 1960-х роках початок створення перших систем стратегічної протиракетної оборони привів до виникнення певного дисбалансу у стратегічному паритеті ядерних сил між Радянським Союзом та Сполученими Штатами. Таким чином дипломатична сторона в Договорі про протиракетну оборону було підписано під час Московського саміту в 1972 році. Цей підхід не лише зафіксував існуючий баланс сил, але й відкрив шлях для дипломатичних діалогів, які сприяли економічним і культурним обмінам. Завдяки цим стратегіям стало можливим створення умов, що зменшували ризик безпосереднього військового зіткнення, показуючи, що навіть у періоди загострення конфлікту високий рівень дипломатії може бути досягнутий і підтримуватиме мир. Роль НАТО в період встановлення цих дипломатичних зв'язків окреслювала рамки, в яких обидві держави прагнули контролювати зростаючий арсенал ядерної зброї, визнаючи, що забезпечення безпеки шляхом безпосереднього знищення запасів озброєнь може призвести до катастрофічних наслідків.

Згодом угоди SALT, перша з яких була укладена в 1972 році, продовжили цей діалог, зосереджуючи увагу на обмеженні кількості стратегічних ядерних озброєнь. Ці дипломатичні зусилля з боку НАТО мали на меті не лише зрівноважити військові можливості, а й створити умови для подальших переговорів щодо контролю озброєнь, які включали механізми верифікації та звітності. Окрім цього, вони стали важливим фактором у легітимзації НАТО як основної платформи для колективної безпеки в Європі, оскільки альянс демонстрував свою здатність вести конструктивний діалог навіть у воєнний період. Це, у свою чергу, заклало основи для майбутніх ініціатив в області безпеки та стратегічної стабільності, підкреслюючи продовження важливості дипломатії в умовах геополітичних змін. Таким чином, дипломатія НАТО в контексті угод ABM і SALT стала не лише показником зусиль до зменшення ядерної загрози, але й виявом інноваційного підходу до міжнародної безпеки, що може слугувати довгостроковим засобом підтримання миру в Європі. Ці надзвичайно складні конструкції взаємодії продемонстрували, що навіть у найскладніших обставинах, політика безпеки може і повинна базуватися на принципах співпраці та діалогу.

3. Вплив євроінтеграції на безпекову дипломатію

Постхолодна війна, що розпочалася на початку 1990-х років, змусила європейські країни переосмислити свої підходи до безпекової дипломатії, що виразилося в розширенні НАТО і Європейського Союзу. У контексті економічної і політичної трансформації країн Східної Європи, які вийшли з-під радянського впливу, НАТО започаткувало програму розширення, що включало інтеграцію нових членів, такі як Польща, Чехія та Угорщина в 1999 році. Цей процес не лише сприяв забезпеченню колективної безпеки, а й викликав занепокоєння у Росії, яка сприймала розширення НАТО як загрозу своїм стратегічним інтересам. Ця зміна в геополітичному ландшафті породила нові виклики, зокрема, необхідність розробки механізмів співпраці між НАТО і Росією, з метою уникнення конфліктів і зміцнення безпеки в регіоні.

У другій половині 1990-х років вимоги до безпеки зазнали значних змін під впливом швидкого розвитку різних технологій, зокрема зростає важливість кібербезпеки в міжнародних відносинах. Розширення та активне використання інформаційних технологій у різних сферах життя створило нові можливості для розвитку та вдосконалення дипломатичних процесів, проте водночас призвело до виникнення нових загроз. Країни почали усвідомлювати свою вразливість у сфері інформаційних систем, що сприяло необхідності впровадження нових ефективних стратегій для захисту національних інтересів. Інновації у військових технологіях, зокрема використання безпілотних літальних апаратів, дронів і сучасних систем перехоплення інформації, стали істотною складовою сучасної архітектури безпеки та політики багатьох держав. Значний вплив євроінтеграції полягає не лише в укріпленні оборонних альянсів, а й у формуванні спільних норм і стандартів безпеки. У цьому контексті держави вивчають досвід одна одної, обираючи ефективні стратегії реагування на новітні загрози. Наприклад, спільні аналітичні механізми та програми обміну інформацією між державами-членами показують, як інтеграція може підвищити загальну готовність до криз. Наявність спільних безпекових інструментів і політик також дозволяє посилити політичні та економічні зв'язки між країнами, що в свою чергу зміцнює регіональну стабільність. Тим не менш, незважаючи на зусилля, які вживаються в рамках євроінтеграції, нові загрози вимагають нестандартного мислення та адаптації до швидко змінюваних умов.

Таким чином, етап постхолодної війни відзначився глибокими змінами у системах безпеки та дипломатії в Європі. Глобалізація, що включала розширення військових і економічних об'єднань, поєднувалася з новими викликами, такими як кіберзагрози та необхідність адаптації до швидко змінюваного технологічного середовища. Взаємодія між старими і новими акторами в цих системах стала критично важливою для забезпечення стабільності і миру в регіоні, підкреслюючи значення інновацій і співпраці в контексті сучасної безпекової дипломатії.

Концепція розширення НАТО у 1999 і 2004 роках, коли до альянсу приєдналися країни Центральної і Східної Європи, стало важливим кроком на шляху інтеграції країн, які раніше підпадали під домінування Радянського Союзу. Цей процес не лише зміцнив безпекову архітектуру Європи, але також привів до збільшення напруженості з Росією, яка сприйняла розширення НАТО як загрозу своїм стратегічним інтересам. Паралельно, Європейський Союз активно просував інтеграційні процеси серед нових членів, що також супроводжувалося політичними, економічними та соціальними викликами. Зростаюча взаємозалежність у сфері економіки та безпеки зумовила необхідність адаптації інститутів ЄС до нових реалій, включаючи виклики, пов'язані з нерівномірним економічним розвитком серед держав-членів і питаннями міграції.

Відзначається, що інтеграція нових країн, таких як Болгарія і Румунія у 2007 році, а також Хорватії у 2013 році, супроводжувалася спробами розробити спільні механізми реагування на загрози, як то тероризм та кібербезпека.

У той же час, взаємозв'язок між розширенням НАТО і ЄС поставив перед цими інститутами нові питання, а саме: як забезпечити колективну безпеку на протипагу новим формам агресії, таких як гібридні загрози, культивовані державами, що прагнуть підірвати стабільність Європи. Відзначається, що розширені межі безпеки вимагали вигадливих, багатоаспектних підходів, які поєднують як традиційні військові методи, так і механізми дипломатії. Таким чином, трансформація безпекової дипломатії в епоху глобалізації і розширення, свідчить про необхідність постійного аналізу і адаптації політик до нових реалій, сприяючи створенню більш стійкої архітектури безпеки в Європі на фоні швидких змін у міжнародному середовищі.

Дипломатичні практики інтеграції, наприклад як Спільна зовнішня та безпекова політика (Common Foreign and Security Policy, CFSP) Європейського Союзу формувалась поступово, у відповідь на потребу країн-членів говорити єдиним голосом на міжнародній арені. Першим кроком до її створення стала Європейська політична співпраця (European Political Cooperation, EPC) у 1970-х роках, яка ще не мала юридично зобов'язуючого характеру, проте забезпечувала координацію позицій держав-членів щодо ключових зовнішньополітичних питань. Важливим проривом став Маастрихтський договір 1992 року, який формалізував CFSP як другий "стовп" новоствореного Європейського Союзу, виокремивши її як окрему сферу інтеграції поза межами спільного права (*acquis communautaire*). Подальше інституційне посилення CFSP відбулося із підписанням Амстердамського договору 1997 року, що запровадив посаду Високого представника з питань спільної зовнішньої політики та безпеки. Згодом, Лісабонський договір 2009 року закріпив CFSP як ключовий компонент зовнішньої дії ЄС, створивши Європейську службу зовнішньої дії (European External Action Service, EEAS) тобто дипломатичну службу ЄС. Цей крок сприяв не лише координації дипломатичних зусиль, а й розширив можливості ЄС реагувати на міжнародні кризи за допомогою спільних інструментів, включаючи цивільні й військові місії в межах Політики безпеки і оборони (CSDP) [4]. Незважаючи на поступову інституціоналізацію, CFSP залишається сферою, де консенсус є ключовим принципом ухвалення рішень, що часом обмежує ефективність зовнішньої політики ЄС. Однак протягом останнього десятиліття, особливо на тлі конфліктів на Близькому Сході, анексії Криму та агресії Російської Федерації проти України, країни-члени демонструють більшу згуртованість у питаннях безпеки. Таким чином, CFSP поступово трансформується з механізму координації в інструмент стратегічного впливу, у якому євроінтеграція відіграє не лише економічну, а й геополітичну роль.

Сама ж інституційна система Європейського Союзу має низку органів, які відіграють ключову роль у формуванні безпекової дипломатії. Центральне місце посідає Європейська служба зовнішньої дії (EEAS), відіграє роль як дипломатичний орган ЄС, створений після набуття чинності Лісабонського договору у 2009 році. EEAS координує зовнішню політику та дипломатичні місії Союзу по всьому світу, працюючи під керівництвом Високого представника ЄС із закордонних справ та політики безпеки. Саме ця служба забезпечує оперативну реакцію на міжнародні кризи, готує аналітичні звіти для інституцій та веде переговори з третіми країнами з питань безпеки. Європейська рада, до складу якої входять глави держав та урядів країн-членів ЄС, визначає стратегічні напрямки спільної зовнішньої та безпекової політики. Вона встановлює політичні пріоритети, реагує на глобальні виклики та конфлікти, а також приймає ключові рішення щодо санкцій, дипломатичних ініціатив і місій CSDP. Рада виступає майданчиком для вироблення спільної позиції держав-членів, що особливо важливо в умовах потреби консенсусу в безпекових питаннях. Хоча вона не виконує щоденних дипломатичних функцій, її рішення мають визначальний вплив на зовнішньополітичний курс усього Союзу.

Робота європейський парламенту також має свою роль у формуванні безпекової дипломатії, хоча вона є переважно дорадчою та контрольною. Парламент затверджує бюджет зовнішньої діяльності, оцінює роботу EEAS, обговорює кризи та конфлікти у світі, впливаючи на формування політичної атмосфери навколо безпекових питань. Його резолюції не є обов'язковими, однак вони часто формують публічний і політичний тиск на інші інституції ЄС. Загалом, так званий трикутник EEAS - Європейська рада - Європейський парламент створює складну, але ефективну модель формування і реалізації безпекової дипломатії Євросоюзу, яка з кожним роком стає більш згуртованою та проактивною.

Реалізація безпекової політики Європейського Союзу стикається з низкою структурних і політичних викликів, що ускладнюють формування єдиного підходу до міжнародної безпеки.

Одним із головних викликів є потреба досягнення консенсусу між усіма державами-членами при ухваленні зовнішньополітичних рішень, що суттєво уповільнює реакцію ЄС на кризи. Інтереси країн-членів нерідко розходяться через відмінності в географічному розташуванні, історичному досвіді, рівні загроз та пріоритетах. Наприклад, для країн Балтії головною загрозою є агресивна політика Росії; для південних держав найактуальнішими питаннями є міграція та нестабільність у Північній Африці. Ще однією проблемою є фрагментація європейських оборонних ресурсів та відсутність повної стратегічної автономії. Навіть попри те, що ЄС запровадив такі ініціативи, як Постійне структуроване співробітництво (PESCO) та Європейський оборонний фонд, вони ще не забезпечують достатнього рівня інтеграції чи ефективності. В результаті більшість держав-членів досі розглядають НАТО як свій головний щит безпеки, що створює подвійність у системі стратегічного планування. Це призвело до тиску між прихильниками посилення ролі ЄС в обороні та тими, хто боїться дублювання зусиль або підриву трансатлантичних зв'язків.

Більше того, безпекова дипломатія ЄС часто є неефективною, коли протистоїть авторитарним режимам, які діють агресивно та не реагують на традиційні дипломатичні інструменти, такі як санкції чи переговори. ЄС часто стикається із завданням одночасно підтримувати турботливу єдність щодо енергетичних інтересів, торгівлі чи співпраці зі своїми сусідами з третіх країн, де міркування безпеки суперечать економічним інтересам. Ці суперечності вимагають не лише інституційних удосконалень, а й глибшого перегляду стратегічної культури Європейського Союзу, точніше переходу від реактивної дипломатії до проактивного формування архітектури глобальної безпеки.

Постхолодна війна спонукала європейські країни переосмислити безпекову дипломатію, що виявилось в розширенні НАТО та Європейського Союзу. Інтеграція країн Східної Європи, зміцнила колективну безпеку, але водночас викликала занепокоєння з боку Росії. Виклики сучасності, зокрема кібербезпека, вимагають нових стратегій для захисту національних інтересів. Інновації у військових технологіях, таких як безпілотники, стають важливими в архітектурі безпеки, що підкреслює необхідність співпраці між країнами. Незважаючи на прогрес у євроінтеграції, нові загрози вимагають адаптації до швидко змінюваного середовища. Зміни в дипломатичних практиках, зокрема розвиток Спільної зовнішньої та безпекової політики ЄС, відображають спроби країн-членів діяти єдиним голосом. В той же час, досягнення консенсусу між державами-рідними учасниками часто затримує реакцію на кризи. Ці виклики підкреслюють потребу в проактивному підході до формування стратегії глобальної безпеки в Європі.

4. Сучасні виклики та перспективи до 2024 року

Європа дедалі більше стикається з дедалі більшою загрозою з боку кібератак, а також більш традиційних та інноваційних сил, таких як асиметрична війна чи тероризм, де не видно чіткого ворога. Водночас зростає напруженість між центрами світової влади та іншими силами Європи, такими як тероризм, порушення енергетичної безпеки та нелегальна імміграція, що відбувається в усьому світі, а також захист інформації, що є деякими прикладами. З 2020 по 2024 рік усі ці виклики виходили за рамки традиційної дипломатії у зовнішній політиці, змушуючи європейські інституції створити нову стратегію зовнішньої дипломатії, яка поєднує оборонну співпрацю, механізми санкцій та гнучку систему реагування на нетрадиційні загрози безпеці. Після того, як Російська Федерація розпочала повномасштабне вторгнення в Україну, Європейський Союз та НАТО швидко активізували дипломатичні зусилля, щоб залучити всі сторони до переговорів, підтримали Україну та запропонували всіляку допомогу. Одним з центральних викликів є терористичні групи, несанкціоновані державою, які тепер стали систематичними. Це включає, зокрема, кібератаки на урядові структури та інфраструктуру, що становить життєво важливий інтерес для країни, а також на приватні підприємства.

У відповідь ЄС запроваджує низку ініціатив, яка отримала відповідальність за нагляд за стратегічними комунікаціями, тим самим розширила спільні механізми виявлення втручання з боку третіх країн та розробила різні структури для поширення інформації через спільні платформи. Європейський Союз зараз все більше і більше інтегрує цифровий вимір у свою безпекову дипломатію, визнаючи кіберпростір повноцінною стратегічною сферою. Зі свого боку, НАТО також впроваджує програмне забезпечення, яке дозволяє йому розпізнавати різноманітні нові загрози. Кіберзагрози та гібридна війна є серед його пріоритетів у цій новій структурі, як зазначено у Стратегічній концепції НАТО 2022 року [5]. Міжвідомчі координаційні центри Альянсу з протидії дезінформації та колективні інструменти для проектів кіберзахисту є прикладами

того, як Альянс просувається вперед на цих фронтах. Також можна спорстерігати як часто проводяться зустрічі з ЄС з цих питань.

Допомога державам-членам та партнерам (включаючи Україну) у подоланні гібридних викликів стала ключовим пріоритетом дипломатичної роботи НАТО [6. с. 21]. Це відображено як в активній політичній підтримці, так і в технічній підтримці, зокрема в кіберзахисті. До 2024 року методи застосування безпекової дипломатії в Європі визначені різними новими загрозами, які спочатку мають бути включені до стратегічного планування та роботи в рамках усіх інституцій. НАТО та ЄС разом з країнами-партнерами на передовій гібридної війни, такими як Україна, Литва, Естонія чи Польща, є особливо важливими для цих процесів. Не менш важливим є знищення аналітичних можливостей, додавання «цифрової дипломатії» та залучення недержавних суб'єктів до формування політики безпеки. Зокрема якої, є важливим залучення ЗМІ, організацій громадянського суспільства та технологічний сектор. В результаті, рух європейської безпекової дипломатії зазнав глибокої трансформації. Її майбутнє полягає в традиційних дипломатичних методах у поєднанні із сучасними інструментами в таких сферах, як інформаційна, кібербезпека та енергетична безпека. Дипломатія зараз дедалі більше стає інструментом стримування в нових обставинах, а також елементом опору згубному впливу та захисником європейського демократичного простору.

Протягом останнього десятиліття міграційні кризи стали найбільшою темою суперечок у європейській безпековій дипломатії, особливо враховуючи події до 2024 року. Біженці з Близького Сходу та Африки, Україна з 2022 року, лише посилили тиск на системи соціального забезпечення, а також на саму європейську солідарність. Балансування гуманітарних обов'язків у сфері національної безпеки є основою державної політики, створюючи таким чином сфери дипломатичних навичок між окремими державами-членами, а також у ширшому євроатлантичному контексті.

Ризики для внутрішньої стабільності внутрішньої політики в багатьох європейських країнах значно поглибилися. Спалахи популізму, зростання ультраправих сил і навіть просто «популярні» ксенофобські настрої чинили тиск на уряди, орієнтовані на Європу, які проводили політику відкритих міграційних дверей з метою отримання більшої кількості голосів у своїх країнах. Завдяки такій атмосфері безпекова дипломатія має мати справу не лише із зовнішніми загрозами, а й із суспільними питаннями в Європі, від конфліктів між сусідніми країнами, наприклад, до ризиків радикалізації. Інтегруючись у дипломатичний дискурс, традиційні концепції безпеки таким чином розвиваються.

До 2024 року перспективи європейської дипломатії у сфері безпеки для вирішення міграційних проблем полягали в тому, що вона дедалі більше застосовуватиме збалансований та стратегічний підхід до реагування. По суті, це означало, що двосторонні домовленості з транзитними країнами мали стати головним пріоритетом. Це має включати інвестиції в розвиток країн, звідки походять мігранти, та запобігання конфліктам, які створюють нові хвилі мігрантів. Усе це призвело до того, що міграційна безпека стала повністю інтегрованою в широкий процес європейської дипломатії безпеки.

Таким чином у контексті нових викликів європейська безпекова дипломатія до 2024 року зазнала суттєвих змін, зокрема через інтеграцію цифрових технологій та вдосконалення кризової комунікації. Цифрова дипломатія стала істотним інструментом для зміцнення міжнародної репутації, своєчасного реагування на інформаційні атаки та формування позитивного іміджу країн ЄС та їх партнерів, включаючи Україну. Вона надає можливість урядам та дипломатичним службам діяти в режимі реального часу, мобілізуючи підтримку, пояснюючи свої позиції та спростовуючи дезінформацію. Онлайн-платформи, соціальні мережі та спеціалізовані цифрові інструменти стали важливими засобами проактивної участі в глобальному дискурсі.

Кризова комунікація, в свою чергу, набула особливої ваги в умовах війни, терористичних загроз і кіберінцидентів. Європейські інституції, зокрема Європейська служба зовнішньої дії (EEAS), активізували розробку стратегій інформаційного реагування на надзвичайні ситуації. Уряди держав-членів зосередили свої зусилля на формуванні єдиної політики інформування, яка забезпечує довіру суспільства під час криз, незалежно від того, чи йдеться про збройні конфлікти, енергетичні кризи чи масштабні кібератаки. Таким чином, дипломатія перестала бути виключно прихованою діяльністю і дедалі більше зосереджується на публічній відкритості та стійкості до інформаційного тиску.

Загалом, модернізація дипломатичних механізмів має на меті підвищення гнучкості та ефективності дипломатії в світі, де інформація, швидкість реагування та довіра відіграють ключову роль. Поєднання цифрової дипломатії та кризової комунікації, яка дозволяє державам формувати комплексну політику безпеки не лише через класичні дипломатичні канали, а й у глобальному цифровому просторі. Це відкриває нові можливості для трансатлантичної співпраці, оперативного реагування на загрози та зміцнення легітимності міжнародних рішень у боротьбі за стабільність та мир у Європі.

Висновки

Після Другої світової війни світова система міжнародних відносин увійшла в нову еру, сформовану Ялтинсько-Потсдамськими домовленостями. Саме вони заклали основи для біполярного світового порядку, в якому США та СРСР визначали свої сфери впливу, що суттєво змінило характер дипломатії та системи безпеки. Виникнення НАТО як безпекового альянсу стало ключовою відповіддю Заходу на ці зміни, закріпивши принцип колективної оборони та стимулюючи єдність у протистоянні потенційним загрозам. Одночасно з цим, економічне відновлення Західної Європи за допомогою Плану Маршалла не лише зменшило радянський вплив, а й дало імпульс до створення нових форм співпраці, зокрема Європейської економічної спільноти. Особливе значення в цьому процесі відіграла Німеччина, яка стала епіцентром нових геополітичних реалій. Поділ її території між чотирма державами-переможцями не лише визначив кордони нового світового порядку, а й сформував дві різні соціально-політичні моделі на одній національній основі. Західна Німеччина стала прикладом успішної модернізації й інтеграції в західний блок, тоді як Східна символом жорсткого контролю та економічних труднощів у межах радянського впливу. Цей контраст підкреслив важливість стратегічного позиціонування країни у світовій політиці та її участі у формуванні нових альянсів, що визначали архітектуру європейської безпеки на десятиліття вперед.

У статті розглянуто, як у післявоєнній Європі відбувся поділ між капіталістичним Заходом і соціалістичним Сходом, який сформував нову геополітичну реальність, що стала основою для розвитку безпекової дипломатії. Виникнення безпекових альянсів, таких як НАТО і Варшавський договір, відобразило прагнення до стабілізації регіону та стримування конфліктів. Ці структури не лише координували військову політику, а й трансформували уявлення суспільств про безпеку, заклали основи дипломатичних механізмів, спрямованих на мирне співіснування. Ключові наведені в статті кризи Холодної війни, стали переломними моментами для міжнародної дипломатії. Вони продемонстрували, що поряд із військовими стратегіями критичну роль відіграють психологічні, ідеологічні та інформаційні інструменти. Ці події пришвидшили створення інституційних каналів комунікації та спонукали до активізації міжнародних організацій, таких як ООН, у сфері врегулювання конфліктів.

Врешті, Холодна війна стала етапом становлення комплексної дипломатії, що базувалась на концепції стримування, ядерного балансу та колективної безпеки. Події у Чехословаччині 1968 року засвідчили потребу гнучких стратегій, де військова присутність поєднувалась з дипломатичним тиском і багаторівневою співпрацею. Таким чином, безпекова дипломатія періоду Холодної війни стала прообразом сучасної європейської політики безпеки, орієнтованої на попередження ескалації та збереження стабільності в умовах глобальних викликів.

У статті досліджено, як у постхолодну епоху європейська безпекова дипломатія зазнала суттєвих трансформацій, що стали відповіддю на зміну геополітичного середовища. Розширення НАТО та ЄС інтегрувало країни Центральної і Східної Європи у нову безпекову систему, проте водночас загострило відносини з Росією. Зростання кіберзагроз, розвиток новітніх військових технологій і гібридні виклики поставили перед європейськими державами нові завдання, вимагаючи гнучкості, інновацій і посилення міждержавної координації. У цих умовах євроінтеграційні процеси стали не лише політичним проєктом, а й інструментом забезпечення регіональної стабільності. Європейський Союз поступово інституціоналізував свою безпекову дипломатію через створення механізмів, таких як CFSP і EEAS, які покликані формувати спільну зовнішню політику. Однак, необхідність консенсусу, відмінності в національних інтересах та брак стратегічної автономії обмежують ефективність цих структур. Попри це, ЄС продовжує рух у напрямку поглиблення співпраці в сфері безпеки, зокрема через оборонні ініціативи та антикризові місії. Сучасні виклики висвітлюють потребу в переході від реактивної до проактивної дипломатії, здатної формувати нову архітектуру безпеки у світі зростаючих загроз.

Підсумовуючи, досліджено, що європейська безпекова дипломатія до 2024 року зазнала глибокої трансформації, реагуючи на нові виклики від гібридних загроз і кібератак до міграційних криз і тероризму. Ці загрози вийшли за межі традиційної дипломатії, змусивши інституції ЄС і НАТО розробити багаторівневу систему реагування, що поєднує цифрову дипломатію, санкційні механізми, кризову комунікацію та підтримку партнерів, таких як Україна. Кіберпростір, інформаційна безпека та захист критичної інфраструктури стали невід'ємною частиною стратегічного планування. Разом з тим, внутрішні виклики, зокрема радикалізація, популізм і міграційні напруження, посилили потребу в комплексному підході до дипломатії, яка охоплює як зовнішній, так і внутрішній виміри. Цифрові технології й активна участь суспільних акторів стали новим стандартом, а сама дипломатія інструментом стримування, стабілізації та відстоювання демократичних цінностей у мінливому безпековому геополітичному середовищі.

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PROSPECTS FOR THE IMPLEMENTATION OF JOINT PROJECTS IN THE FIELD OF SUSTAINABLE DEVELOPMENT BETWEEN INDEPENDENT AND NEUTRAL TURKMENISTAN AND THE FRENCH REPUBLIC

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Abstract

The main directions of Turkmenistan's cooperation with the countries of the European Union are considered. The expediency of further realizing the existing potential in the field of urban development, monitoring of methane emissions, "green" and hydrogen energy, and education between Turkmenistan and the French Republic is substantiated. We have to conclude that it is necessary to expand activities in the field of science and culture between the two friendly countries.

Keywords: *International partnership, neutrality, European Union, advanced French companies, memorandum of cooperation*

As you know, Turkmenistan is an independent and neutral state. In March 2025, the United Nations General Assembly adopted a resolution recognizing Turkmenistan's neutrality for the third time. Based on this legal status, our country has been pursuing an "open door" policy and broad international cooperation based on the principles of equality and mutual respect for many years. At the initiative of the esteemed President of Turkmenistan, Serdar Berdimuhamedov, 2025 was declared the "International Year of Peace and Trust", which was supported by members of the international community, including the leadership of the French Republic. Regarding the geopolitical situation, Turkmenistan, along with Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan, is one of the countries of Central Asia. Our country also borders Iran and Afghanistan. Our state maintains good-neighborly relations with neighboring States, which are based on a reliable and solid foundation of mutually beneficial economic cooperation. Thus, according to the statistical indicators of the International Monetary Fund, our country is included in the rating of economically developing countries. To achieve this level, state programs are being adopted and implemented at the state level to create favorable economic conditions for foreign companies interested in investing in the development of various sectors of the national economy. In this way, the following state programs are being successfully implemented in the field of development of the oil and gas, gas chemical, agricultural and construction industries: "The program of industrialization of the country for the period up to 2030" and "The National Program of socio-economic development of the country up to 2052"[1].

The country has also established a regulatory framework that provides legal guarantees and reliable investments. It complies with generally accepted norms of international law. Our country actively participates in partnership formats with the European Union (EU), including on the Central Asia–EU platform. In this regard, it is necessary to emphasize the importance of the First Summit in this format held in April 2025 in the city of Samarkand, which emphasized the relevance of interregional cooperation on issues such as peace, security and stability. The summit discussed the possibilities of expanding sectoral cooperation in economic, trade and investment relations based on the implementation of current and future bilateral Cooperation Agreements. Four key areas have been identified that are the most promising for joint work: transport infrastructure, critical raw materials, clean energy and digital communications. The Central Asian countries have impressive reserves of critically important raw materials. The region contains 40% of the world's reserves of manganese, as well as lithium and graphite. These materials are necessary for the "green" and digital transformation of the global economy. In addition, this region has a unique potential in the field of renewable energy. The importance of digital equality was highlighted, as well as the development of projects to connect remote regions of Central Asia to the EU satellite Internet. In the field of communications, we also proceed from the necessity and

possibility of laying cables along the bottom of the Caspian Sea. Turkmenistan generally believes that the construction of underwater infrastructure in the Caspian meets the economic needs of coastal States and is an important condition for ensuring energy, economic and transport stability in Eurasia based on equal consideration of interests and benefits.

It is most appropriate to support ongoing efforts to ensure sustainable transport connectivity and strengthen economic ties through initiatives within the framework of the Global Gateway strategy. In this context, it is necessary to note the progress in the creation of the Trans-Caspian Transport Corridor connecting Europe and Central Asia using the potential of the International Seaport of Turkmenbashi on the shores of the Caspian Sea. Considering that water use is one of the key issues in the Central Asian region, our country proceeds from three principles in considering this issue: compliance with international law; mutual consideration of the interests of all States in the region; participation of international organizations, primarily the United Nations. The EU and Central Asia, which will contribute to strengthening sustainable transport links as a driving force for economic growth and regional integration. To enhance cooperation in the field of energy and the green transition, the EU-Central Asia Declaration of Intent on Sustainable Value Chains for Critical Raw Materials was approved. Turkmenistan is committed to developing and expanding cultural and humanitarian cooperation with European countries. It is necessary to note the effectiveness of educational projects and programs that have been implemented by the EU in our country for many years. Among them are such large-scale programs as TACIS-TEMPUS, ERASMUS-MUNDUS, DARYA. In particular, more than 40 projects in the field of master's degree programs, digitalization in education, support for sustainable development and academic mobility have been implemented in Turkmenistan within the framework of the ERASMUS-MUNDUS and ERASMUS+ programs. In the development of this work, responding to objective requests and needs for cooperation, joint projects in the field of vocational education are promising. The training of highly qualified technical personnel working at enterprises with high-tech equipment is important for the creation of innovative products and technologies. Thus, Turkmenistan's well-thought-out economic strategy, a favorable investment climate and conditions for effective cooperation increase its attractiveness to the global business community, which is why many foreign companies are showing great interest in working in the promising Turkmen market.

In the modern period, the international relations between neutral and independent Turkmenistan and the French Republic indicate the mutual commitment of the parties to bring mutually beneficial cooperation in all areas to a qualitatively new level. Therefore, at the Turkmen-French economic forum, which took place in early May 2025, further ways of expanding bilateral economic, social and humanitarian ties were comprehensively studied. The forum aimed at the effective use of trade and economic potential was attended by the heads of leading French companies and members of the Turkmen delegation. The expansion of mutually beneficial cooperation with large French companies is one of the priorities of our country's foreign economic strategy. Thus, the activities of the French company Bouygues in Turkmenistan are evidence of the effectiveness of established business cooperation as a result of the successful implementation of numerous joint construction and architectural projects. This company, which has been operating in our country since the first years of independence, also makes a significant contribution to the expansion of international educational ties, as well as to the teaching of French in the country. For example, there is a specialized French language school in Ashgabat, built by this company. Also, over the years of independence, constructive cooperation has been established with such large French companies as Cifal, Vinci, Schneider Electric and others. The experience gained during the joint work with its positive results point to the prospects of the future bilateral partnership.

As experts point out in their scientific research, the economy of the French republic is characterized by a diversified and integrated industrial base, advanced technologies and in accordance with environmental requirements. Thanks to the National Investment Program launched in 2010, the country has seen an improvement in the quality of higher education and training, scientific research, and accelerated innovative development of industry, medium and small businesses, the digital economy, and environmental technologies. The creation of innovation clusters, the reform of university education, and favorable tax refund conditions for specialists in conducting research and development (R&D) create favorable conditions for doing business. France is favorable for international cooperation due to the availability of highly qualified specialists, well-developed infrastructure, as well as support from government authorities [2, 3].

In 2013, the country adopted the Law on Higher Education and Scientific Research. It aims to democratize higher education, open access to knowledge, and support students in studying at universities, regardless of socio-cultural background, age, and financial status. Admission to universities

becomes possible for those who have received "professional" and "technological" bachelor's degrees. The number and size of scholarships have been increased, especially for those from families with modest incomes. Professional orientation in the first years of higher education has been strengthened, special attention has been paid to the development of digital technologies. The law is aimed at developing links between universities, schools and research centers, and achieving greater international recognition of French universities, university education, and scientific research. The possibility of teaching in foreign languages is being consolidated, in particular, within the framework of agreements with foreign universities and programs funded by the EU. Conducting research independent of the economic situation has become possible due to the simplification of the procedure for introducing scientific achievements into the economy and production, as well as strengthening the role of the state in consolidating fundamental research and ensuring their financing.

The French Republic is an economically developed country that is currently investing in the following five strategic areas in order to increase the competitiveness of all sectors of the national economy and prepare the basis for their sustainable development in the future:

- Higher education and specialist training. It is planned to create from five to ten universities in the country and turn the Plateau de Saclay research site into the largest center in the EU for training scientific and technological specialists;
- Scientific research. It is planned to create medical research institutes within universities, expand the network of scientific laboratories for conducting research on nanotechnology and biotechnology;
- Small and medium-sized businesses, industrial sector. Further development of the aerospace sector, innovative companies and clusters is planned;
- Ecology. Within the framework of the New Environmental Agreement program, various environmental business projects are being implemented: obtaining energy from renewable sources, developing environmentally safe modes of transport and developing a green urban environment, and introducing energy-saving technologies for households;
- Digital economy. It is expected to build a high-speed broadband network, create innovative services and products, in particular, the digitization of French cultural heritage.

In the modern period in France, there is an increasingly intensive introduction of inventions and technologies by the efforts of innovative small and medium-sized businesses. A very centralized structure of innovative research has traditionally been formed in this country. Unlike many European countries, France refuses to pursue a global policy in the field of science and technology with the help of administrative and legal levers and is rebuilding its infrastructure in order to create the most favorable conditions for cooperation between science and production. An effective complex of exploratory and applied research has been created in the country. The national innovation policy is developing in several directions: supporting the innovation activities of small and medium-sized enterprises, removing restrictions on venture capital investments, and stimulating cooperation between scientific organizations, universities, and industrial enterprises. Despite the relative centralization of scientific and technical activities, a regional approach to innovation is also clearly visible. The promotion of innovation in industry is entrusted to the French Innovation Agency, which is located under both the Ministry of Industry and the Ministry of Scientific Research. The agency is characterized by a decentralized structure with broad representation at the regional level [4, 5, 6].

In legal terms, the basis of innovation policy is the French Law on Innovation and research, which aims to transfer the results of research funded by the public sector of the economy to industry and the creation of small innovative enterprises. In France, various innovation support systems have been most developed. Specialized innovation structures have been created at the regional level (technoparks, business incubators, agencies and technology transfer centers). The French Ministry of Scientific Research has established more than 150 specialized centers for regional innovation and technology transfer. Each center specializes in a specific area of expertise and industry. In some regions of France, innovative development within the framework of the formation of modern scientific centers is carried out through the creation of high-tech technology parks, and they are formed not only in industrially developed departments, but also in those where the economy had a mono-product orientation (for example, winemaking, tourism).

It should be noted that "TurkmenAlem 52°E" is the first Turkmen communications satellite built by the French company "Thales Alenia Space" based on the Spacebase satellite platform. It was launched in April 2015 from Cape Canaveral (USA). The satellite is located in geostationary orbit and covers most of Europe, Central Asia and the Middle East with its signal. Undoubtedly, the presence of its own satellite has positively influenced the development of communication systems and the Internet, television in the

country, contributed to the implementation of environmental programs, improved methods of exploration of new deposits, as well as the successful implementation of a number of other government programs. As a satellite operator, a closed-type Auction Company (JSC) "Turkmen Khemrasy" offers telecom operators, TV and radio companies and other participants in the satellite communications market access to the capacity of the space segment. The resources of the "Turkmen Alem 52°E" communications satellite provide extensive opportunities for organizing communication services and digital broadcasting, creating VSAT networks, broadband Internet access, and organizing departmental and corporate communications networks in the satellite's coverage area. In 2018, "Turkmen Khemrasy" JSC built its own FSS Teleporter and deployed a VSAT network based on Newtec Dialog, which made it possible to effectively use the satellite's capacity and increase the number of its users, as well as improve the quality of services provided and data transmission volumes. In addition, "Turkmen Khemrasy" JSC is actively working in the field of broadcasting, able to meet the needs of the population for the highest quality television content [7].

Thus, our country is interested in attracting advanced French experience in the field of urban development, monitoring of methane emissions, geological exploration, supplies of oil and gas equipment, "green" and hydrogen energy. It is advisable to continue the practice of holding international events such as the energy forum held in Paris in 2024. Taking into account France's leading position in the global tourism sector and Turkmenistan's significant tourism potential, it is advisable to establish cooperation in this area. The following documents were signed in 2025:

- Memorandum of Understanding between "Turkmenaragatnaşyk" Agency of the Agency for Transport and Communications under the Cabinet of Ministers of Turkmenistan and "Airbus Defense and Space SAS" company;
- Framework agreement between the "Turkmenaragatnaşyk" agency of the Agency for Transport and Communications under the Cabinet of Ministers of Turkmenistan and "Thales Alenia Space France" company on the operation of the "Turkmen "Älem 52° E-2" telecommunications satellite;
- Memorandum of Understanding between the Ministry of Agriculture of Turkmenistan and "IGN FI" company on cooperation in the field of land cadastre and remote monitoring of agricultural crops;
- Memorandum of Understanding between the State Committee of Water Resources of Turkmenistan and "SUEZ International" company on cooperation in the field of rational use of water resources;
- Memorandum of Understanding between "Turkmengaz" State Concern and "SUEZ International" company on cooperation in the gas industry;
- Memorandum of Understanding between "Turkmengaz" State Concern and "Kayrros SAS" company;
- Declaration on cooperation in the field of sustainable urban development between the Government of Turkmenistan and the Government of the French Republic;
- Roadmap for cooperation in the field of education and higher education institutions for 2025-2026 between the Ministry of Education of Turkmenistan and the Ministry of Europe and Foreign Affairs of the French Republic;
- Agreement between the Ministry of Culture of Turkmenistan and the National Museum of Natural History of France on cooperation in the field of archaeological research;

These documents will be of great importance for the development of interstate relations.

Thus, the following are identified as promising areas for further Turkmen-French partnership: oil and gas complex, satellite communication technologies, transport, construction, water resources, chemical industry, educational sector and agriculture.

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Technical sciences

EXPERIMENTAL STUDY OF HYDRAULIC RESISTANCES IN PIPES MADE OF PARALLEL JOINTED PLASTIC MASS USED IN TRANSPORTATION OF OIL AND OIL PRODUCTS

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Abstract

The transportation of oil and oil products through pipelines requires materials and designs that ensure minimal hydraulic resistance, durability, and efficiency under varying operational conditions. This study presents an in-depth experimental investigation into the hydraulic resistances encountered in pipes manufactured from parallel jointed plastic mass — a modern polymer-based material increasingly adopted in pipeline systems due to its corrosion resistance, lightweight nature, and cost-effectiveness.

The objective of this research is to determine the hydraulic behavior of such plastic pipes when used for transporting crude oil and its derivatives. A series of experiments were conducted to evaluate how pipe geometry, flow velocity, fluid viscosity, and internal surface characteristics influence pressure losses and flow uniformity. The test bench was equipped with flow meters, pressure sensors, and temperature control units to simulate realistic operational environments and collect precise measurements under controlled conditions.

Key experimental parameters included varying the internal diameters of the plastic pipes, adjusting the fluid flow rates, and using oil products of different viscosities. The flow regime was carefully monitored to distinguish between laminar and turbulent conditions. The results were then compared with classical theoretical models, including the Darcy–Weisbach and Hazen–Williams equations, to assess the deviation of experimental data from standard hydraulic resistance predictions.

The study revealed that parallel jointed plastic pipes exhibit lower hydraulic resistance compared to traditional steel and cast-iron pipes, particularly under laminar flow regimes. However, surface roughness due to jointing and microstructural inconsistencies introduced minor turbulence at higher velocities, resulting in increased pressure drops. The correlation between Reynolds number and friction factor was established for the tested material, allowing for a better prediction of head losses in practical pipeline design.

Furthermore, the influence of temperature on oil viscosity and its effect on hydraulic resistance was evaluated, revealing that temperature management plays a significant role in maintaining flow efficiency. Based on the findings, recommendations for optimal flow rates and installation practices are proposed to minimize resistance and enhance the energy efficiency of oil transportation systems using plastic pipes.

This research contributes valuable empirical data for engineers and designers working with polymer-based pipeline systems and offers insights for improving the hydraulic performance of pipelines in the oil and gas industry. Future studies may focus on long-term durability, erosion effects, and dynamic response under fluctuating pressure loads.

Keywords: Hydraulic resistances, oil products, pipe, transportation, flow

Introduction. As is known, the correct organization of the work of hydraulic systems depends on their design and reporting. To study the hydraulic resistance in parallel connected plastic pipes of different diameters and different lengths, in other words, to establish the dependence of the pressure drop on the flow, it is first necessary to assemble an experimental device. To assemble the device, first of all, the information available in the literature in this direction was analyzed. Then, the experimental laboratory capabilities for the object under study were investigated, including the material and technical base of the laboratory, its hermeticity (first of all, it should not affect other scientific research laboratories located in the vicinity).

Considering the above, the chapter under consideration of the dissertation work is divided into sections of different diameters ($l_1=1.4$ m, $l_2=1.2$ m, $l_3=1.0$ m) and various lengths ($d_1=20$ mm, $d_2=25$ mm, $d_3=32$ mm) of plastic pipes are devoted to the experimental study of hydraulic resistance (dependence of pressure drop on flow). As is known from the literature, a series of scientific works have been carried out on the study of hydraulic resistance of parallel connected pipes. However, in connection with the development of science and technology, there is a need for experimental study of hydraulic resistance in pipes and fittings of various lengths and diameters produced as a result of new technological processes. Because, it would be incorrect to design hydraulic machines without knowing the values of hydraulic resistance. Scientific research works conducted in this direction at the "Mechanics" department of Azerbaijan Oil and Industry University, one of the leading higher educational institutions of our Republic, are a vivid example of this. Before experimentally studying the hydraulic resistance of plastic pipes of different diameters and different lengths connected in parallel in the assembled experimental device, the linear hydraulic resistance of the plastic pipe with a continuous indicator was studied in that device and the results obtained were checked with reliable literature sources. In this regard, the research objects, diameters and lengths of the pipes were changed in the assembled device, and experiments were conducted in the experimental device without changing the measuring devices.

METHODOLOGY: EXPERIMENTAL DEVICE FOR STUDYING HYDRAULIC LOSSES IN PARALLEL JOINTED PIPES MADE OF PLASTIC MASS

As is known, experimental devices for experimental study of hydraulic resistances must meet the specific requirements intended for conducting experiments. For this purpose, firstly, since the experimental device has a rotating part, safety regulations must be strictly observed, secondly, in parallel connected pipes of different diameters and lengths, it must be convenient to change the flow rate to establish the dependence of hydraulic resistance and pressure drop on the flow rate, thirdly, the experimental device must have the ability to change the objects of study, fourthly, the measuring devices (flow rate measuring manometers, etc.) placed in the experimental device are placed at such an optimal distance that it is possible to create a stationary regime. For this purpose, the initial distance in laminar mode motion is taken as $l_{head} = 0.029d \cdot Re$, for turbulent mode motion this distance is taken as $l_{head} = (40 - 50)d$.

Experimental setup that meets the above requirements The scheme of the experimental device assembled in the scientific and research laboratory of the "Mechanics" department of AzTU is shown in Figure 1.

The experimental setup consists of three main parts: pressure generation, regulation and measurement parts. In Figure 3.1, 1, receiving tank; 2,4,5, valves; 3 - pump; 6- water flow meter (Meter, brand BKCM, 90 and SQV, 15); 7, 8, 10, 11, 12, 14, 15, 17 manometers; 9, 13, 16 research object (Measured pipes, respectively $d_1=20$ mm, $d_2=25$ mm, $d_3=32$ mm and $l_1=1.4$ m, $l_2=1.2$ m, $l_3=1.0$ m plastic pipes) 18- pressure pipe, 19- regulation pipe. The requirements stipulated in the assembled experimental setup were strictly followed. 4.5 valves were used to obtain the appropriate values of the velocity due to the flow change in the cross section of the research object. That is, by changing the cross-sectional area (passage area) of valve 5, a certain part of the liquid is directed to the experimental object by changing the passage area of valve 4 and is directed to the receiving tank through pressure pipe 18. Another important requirement is that the manometers 7 and 11 are placed at a distance of $l = (40 - 50)d$, depending on the fluid flow regime (since the regime of movement is turbulent).

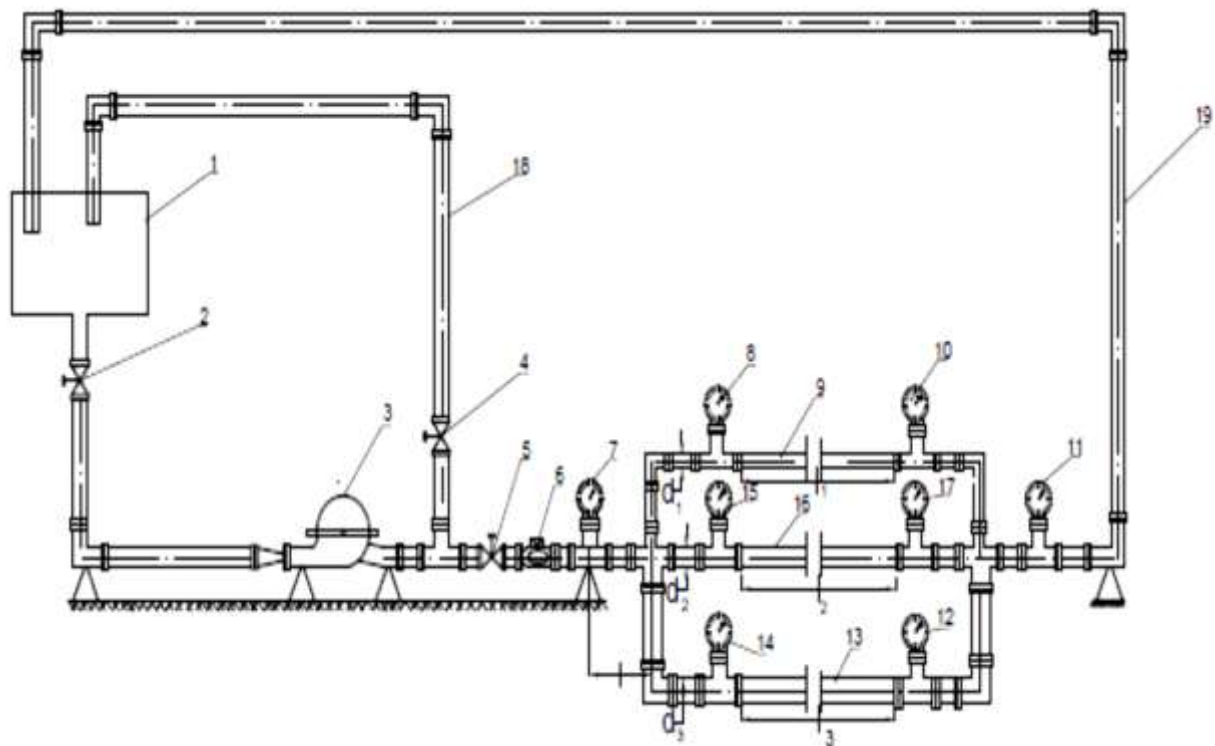


Figure 1. Scheme of an experimental setup for studying hydraulic losses in parallel connected pipes of different diameters and lengths

METHODOLOGY OF EXPERIMENTAL STUDY OF HYDRAULIC LOSSES IN PARALLEL JOINTED PIPES MADE OF PLASTIC MASS

As is known, before starting the main experiment, the operation of separate, separate rotating and measuring devices (the shaft of the electric motor and the impeller of the pump, the liquid flow meter, 6-meter, manometers, 7, 8, 10, 11, 12, 14, 15, 17) is checked. Then the opening and closing of the valves 2, 4, 5 and is checked, and the regularity of the pump's operation, that is, its efficiency, is considered. The stationary nature of the flow in the research object (in the pipes) is checked according to the indications of the manometers.

With the element used in the experimental setup where the experiment is being conducted it is necessary to indicate the main parameters of the equipment (pump, water flow meter, manometers, valves, plastic pipes). The energy source, the pump, is manufactured by foreign companies and is of the brand IDEL PUMPS DTD. This pump is a type of vane pump, centrifugal type, and receives its rotational motion from an electric motor. Since these pumps do not have suction capacity, the receiving tank is located 0.8 m above the pump axis. Another advantage of the reception tank being located above the pump axis is that cavitation does not occur in the pump. (This is described in detail in Chapter II). The main parameters of the pump are as follows.

A) productivity $Q = (5 - 32) \text{ l/min}; (0.083 - 0.53) \text{ l/sec};$

B) pressure $P = (0.5 - 36) \text{ kG cm}^2; (0.05 - 0.36) \text{ MPa};$

C) number of revolutions of the shaft $n = 2900 \text{ revolutions/min} = 48.3 \text{ sec}^{-1}.$

The parameters of the flow meter water meter are as follows:

Brand SQV, 15 000 PKF "BETAR"

SQV, 15 stamps The technical characteristics of the water meter are given in table 1.

Indications of manometers used to measure pressure in the relevant pipes

$P = (0.1 - 0.2) \text{ MPa}.$

The general methodology for conducting experiments is as follows. This methodology is related to the expression of the dependence of hydraulic resistance and pressure drop on flow in parallel connected pipes. This expression is the selection of the graphoanalytic method in parallel connected pipes.

Table 1

No.	Parameter names	Nominal diameter, Dsh, mm	
		15	20
1	Ambient air temperature, °C	From 5 to 50	
2	Relative humidity of ambient air, %	Up to 80	
3	Water consumption, m3/hour		
4	The largest Qmax	3.0	5.0
5	Nominal Qom	1.5	2.5
6	Transition Qt	0.12	0.2
7	The smallest Qmin	0.03	0.06
8	The largest water volume, m3		
9	During the day	37.5	62.5
10	During the month	1125	1875

The parameters measured from the experiment are the readings of the manometers and flowmeters at constant flow rates over time. To find out the pressure difference, the readings of the manometers P7, P8, P10, P11, P12, P14, P15 and P17 are measured, and to calculate the liquid flow rate, the corresponding flow values are measured. The experimental measurements were carried out in the following sequence.

1. Check the condition of the experimental setup by measuring the pressure in the receiving tank 2 without starting the pump.

By opening the valve, water flows into the pump and the connections are

- Attention is paid to leaks;

2. 1 tank of liquid yes After making sure that cmin is equal to the pump's 2-3 minute efficiency, pump 3 is started;

3. Valve 5 is fully closed and valve 4 is fully open. At this time, the pump will operate in idle mode. k is prepared for the main experiment by directing the working fluid 18 through the discharge pipe to the receiving tank;

4. After the steady movement established in the idle mode is obtained, the valve 5 opens in accordance with the step. This is determined by the minimum vibration of the indications of the manometers 7 and 11.

HYDRAULIC ANALYSIS OF PIPELINES

Hydraulic analysis of pipelines is carried out to determine the geometric dimensions of the pipelines. Here, a certain flow rate of fluid, or the hydraulic characteristics of the pipeline, pressure loss and the flow rate of fluid passing through the cross section of the pipe are determined. All these calculations are carried out based on the known dimensions of the pipeline.

During the hydraulic analysis of pipelines in turbulent flow, the Bernoulli equation is used for two flow cross sections.

$$z_1 + \frac{p_1}{\rho g} + \alpha_1 \frac{v_1^2}{2g} = z_2 + \frac{p_2}{\rho g} + \alpha_2 \frac{v_2^2}{2g} + \sum h \quad (1)$$

here $\sum h$ It is the pressure loss between the sections 1-1 and 2-2. In general, the formula (Darcy) named after the first water pipe is used to determine this pressure loss between the sections under consideration.

$$\sum h = \frac{8gLv^2}{c^2 d 2g} = \lambda \frac{L}{d} \frac{v^2}{2g} \quad (2)$$

here λ - is the hydraulic resistance coefficient, and is determined as follows.

$$\lambda = \frac{8g}{c^2} \quad (3)$$

here c It is determined by the formula of Academician N.N. Pavlovsky. Then λ can be calculated as follows.

$$\lambda = \frac{8gn^2}{\left(\frac{d}{4}\right)^{2y}} \quad (4)$$

here n - is the pipe's roughness coefficient.

In formula (2) g when expressing its speed with the known formula, that is

$g = \frac{Q}{f}$, here Q - It is the flow rate of fluid passing through a pipe per unit time and is taken from experience.

$f = \frac{\pi d^2}{4}$ - is the area of the live cross-section of the pipe.

Then a new formula is obtained, which is called the second Sukemeri formula.

$$\sum h = \frac{LQ^2}{c^2 f^2 \frac{d}{4}} = \frac{64LQ^2}{c^2 \pi^2 d^5} = aL \frac{Q^2}{d^5} \quad (5)$$

$$\text{here } a = \frac{64}{c^2 \pi^2} = \frac{64n^2}{\pi^2 \left(\frac{d}{4}\right)^{2y}} \quad (6)$$

Given in diameter d for pipelines Q at the expense of $\frac{aQ^2}{d^5}$ is considered a constant quantity.

That is,

$$\sum h = aL \frac{Q^2}{d^5} = AL \quad (7)$$

The fluid consumption in a determined movement is calculated using the following formula.

$$Q = fC\sqrt{RJ} \quad (8)$$

here J - is the hydraulic gradient and is the loss per unit length.

$$J = \frac{\sum h}{L}$$

R - Hydraulic radius is the ratio of the live cross-section to the wetted perimeter.

$$R = \frac{f}{\chi} = \frac{\pi d^2}{4\pi d} = \frac{d}{4}$$

From expression (8)
$$\frac{Q}{\sqrt{J}} = fC\sqrt{R}$$

For a pipe with a constant cross-section fC and R - is a constant quantity.

$$\frac{Q}{\sqrt{J}} = fC\sqrt{R} = K \quad (9)$$

here K - is a consumption characteristic.

$$K = fC\sqrt{R} \quad \text{or}$$

$$K = f \sqrt{\frac{2gd}{\lambda}} \quad (10)$$

Then $Q = K\sqrt{J}$

If we express the flow characteristic in terms of diameter, then

$$K = fC\sqrt{R} = \frac{\pi d^2}{4} \sqrt{\frac{d}{4}} \frac{1}{n} R^y \quad (11)$$

Here, the strength indicator depends on the hydraulic radius and the coefficient of roughness according to the N.N.Pavlovsky formula. Studies have shown that among the existing empirical formulas, the formula of academician N.N.Pavlovsky is more correct in terms of its structure, i.e.

$$C = \frac{1}{n} R^y = \frac{1}{n} \left(\frac{d}{4}\right)^y \quad (12)$$

here n - is the roughness coefficient, characterizing the roughness of the pipe wall. For plastic pipes, $n=0.011$ was adopted. R - hydraulic radius; y - It is a variable strength indicator and is calculated as follows.

$$y = 2.5\sqrt{n} - 0.13 - 0.75\sqrt{R}(\sqrt{n} - 0.10) \quad (13)$$

Formula (13) is based on experimental data and gives good results in practice. Therefore, currently, satisfactory results are obtained from this formula, especially during calculations in turbulent regime motion.

According to the formula (5) mentioned earlier, K - If we add the consumption characteristics, then

$$\sum h = aL \frac{Q^2}{d^5}, \text{ then } \frac{\sum h}{L} = J = a \frac{Q^2}{d^5} \text{ they}$$

$$\text{from here } \frac{d^5}{a} = \frac{Q^2}{J}$$

$$\text{then } K^2 = \frac{d^5}{a} \quad (14)$$

By taking expression (14) into account in the second water column formula, we obtain the formula for the pressure loss

$$\begin{aligned} \sum h &= \frac{LQ^2}{K^2} \quad \text{or} \\ Q &= K \sqrt{\frac{\sum h}{L}} \end{aligned} \quad (15)$$

It should be noted that for parallel connected pipelines, the sum of the flows between points a and b is equal to their sum in the individual branches, i.e.

$$Q = Q_1 + Q_2 + Q_3 \quad (16)$$

The pressure loss is equal to their difference, and in parallel connected pipes (branches) the same $\sum h_1$, $\sum h_2$ and $\sum h_3$ that is,

$$\sum h_1 = H_A - H_B; \quad \sum h_2 = H_A - H_B; \quad \sum h_3 = H_A - H_B \quad (17)$$

$$\text{From the equality of expression (17), we get that } \sum h_1 = \sum h_2 = \sum h_3 = \sum h \quad (18)$$

These pressure losses can be expressed in terms of consumption as follows.

$$\sum h_1 = K_1 Q^n; \quad \sum h_2 = K_2 Q^n; \quad \sum h_3 = K_3 Q^n \quad (19)$$

where K_1, K_2, K_3 and n are determined depending on the motion mode.

Therefore, the following system equation can be formulated.

$$Q_1 = K_1 \sqrt{\frac{\sum h}{l_1}}; \quad Q_2 = K_2 \sqrt{\frac{\sum h}{l_2}}; \quad Q_3 = K_3 \sqrt{\frac{\sum h}{l_3}} \quad (20)$$

Let us simplify expression (20)

$$Q_1^2 = K_1^2 \frac{\sum h}{l_1}; \quad Q_2^2 = K_2^2 \frac{\sum h}{l_2}; \quad Q_3^2 = K_3^2 \frac{\sum h}{l_3} \quad (21)$$

Let us determine the ratio of costs using expression (21)

$$\frac{Q_2}{Q_1} = \frac{K_2}{K_1} \sqrt{\frac{l_1}{l_2}}; \quad \frac{Q_3}{Q_1} = \frac{K_3}{K_1} \sqrt{\frac{l_1}{l_3}} \quad (22)$$

The pressure loss through the report is calculated using the following formula.

$$\sum h = \frac{Q^2}{\left(\frac{K_1}{\sqrt{l_1}} + \frac{K_2}{\sqrt{l_2}}\right)^2}; \quad \sum h = \frac{Q^2}{\left(\frac{K_1}{\sqrt{l_1}} + \frac{K_3}{\sqrt{l_3}}\right)^2} \quad (23)$$

From expressions (16) and (17) it can be concluded that to establish the complete characteristics of several pipelines connected in parallel, the same $\sum h$ In the value of τ , any point is constructed by summing the values of Q_1 , Q_2 and Q_3 and by the rule $\sum h = \sum h(Q)$ The curve is constructed.

As in turbulent flow, the pressure drop or pressure drop along the length of the pipe in laminar flow is calculated using the well-known Darcy-Weisbach formula.

$$\sum h = \lambda \frac{l}{d} \frac{g^2}{2g}$$

Note that the hydraulic resistance coefficient in laminar flow is theoretically determined by the following formula:

$$\lambda = \frac{64}{Re} \text{ is determined by.}$$

It should be noted that NZFrenkel's experiments have shown that

, λ The experimental values of differ sharply from the theoretical values in individual cases, large diameters and large roughness. In general, the hydraulic resistance coefficient in laminar flow is expressed as follows:

$$\lambda = \frac{A}{Re}$$

here A coefficient based on empirical values $A = f(d, n)$ is accepted. Then the pressure loss in laminar flow is as follows.

$$\sum h = \lambda \frac{l}{d} \frac{g^2}{2g} = \frac{ALQ^2}{Re d 2g f^2} = \frac{8ALQ^2}{Re g \pi^2 d^5} = a \frac{L}{d^5} Q^2$$

dairfor laminar flow in pipes $a = \frac{8A}{Re g \pi^2}$ accepted.

As we mentioned, after experimentally studying the hydraulic resistance in parallel connected pipes of different diameters and lengths, the total flow rate according to the flow meter reading was calculated using the following formula and is given in Table 2.

$$Q = \frac{V}{\tau} \quad (24)$$

here V - volume (amount) of fluid passing through the cross-section of the pipe, m^3 , τ - is the time for the liquid to flow, seconds.

table 2

Row No.	$Q \times 105, m^3/sec$	$P7, kg/cm^2$	$P11, kg/cm^2$	τ, min	$V \times 103, m^3$
1	0	0	0	0	0
2	2.045	0.074	0.059	1.46	3.0
3	1.96	0.071	0.052	1.53	-«-
4	1.75	0.066	0.048	1.72	-«-
5	1.7	0.059	0.048	1.76	-«-
6	1.65	0.054	0.048	1.82	-«-
7	1.5	0.048	0.044	2.0	-«-
8	1.46	0.037	0.036	2.05	-«-
9	1.3	0.03	0.029	2.3	-«-
10	0.96	0.025	0.02	3.12	-«-
11	0.38	0.015	0.013	7.89	-«-

In parallel connected branches, the indications of manometers $P8$, $P10$, $P12$, $P14$, $P15$ and $P17$ were the same. The pressure drop due to the hydraulic resistance in the connections was recorded on manometers $P7$ and $P11$. Using the obtained experimental values, it is possible to calculate the flow in different branches. For this purpose, knowing the value of Q obtained from the experiment according to formula (16), we calculate Q_1 by replacing Q_2 and Q_3 with Q_1 from the system equation according to expression (22) and performing transformations.

$$Q_1 = \frac{Q}{7.75} ; \quad Q_2 = 2.092Q_1 \quad ; Q_3 = 4.66Q_1 \quad (25)$$

For a plastic pipe with a diameter of $d=20$ mm, we calculate $C1$ using formula (12), knowing that $C1=22.04$; we determine $K1$ from formula (11). $K1=0.48$ l/sec. Thus, we determine $C2$, $K2$ and $C3$, $K3$ in the same sequence. That is, $C2=24.02$; $K2=0.93$ l/sec; $C3=26.35$, $K3=1.89$ l/sec. Thus, the results obtained from the calculation based on experimental values are given in table 3.

table 3

Row No.	$\sum h \times 10^2, m$	$Q_1 \times 10^5, m^3 / san$	$Q_2 \times 10^5, m^3 / san$	$Q_3 \times 10^5, m^3 / san$
1	0	0	0	0
2	0.014	0.05	0.1	0.23
3	0.09	0.12	0.26	0.58
4	0.17	0.167	0.36	0.79
5	0.21	0.18	0.39	0.87
6	0.22	0.19	0.4	0.9
7	0.27	0.21	0.442	0.99
8	0.29	0.22	0.46	1.02
9	0.307	0.225	0.47	1.05
10	0.38	0.25	0.525	1.16
11	0.41	0.26	0.547	1.198

In the same coordinate system using experimental and calculated values $\sum h = f(Q_1)$, $\sum h = f(Q_2)$ and $\sum h = f(Q_3)$ graphical dependencies have been established. These dependencies are given in Figure 2. Taking into account the certain regularity of the constructed graphical dependencies, the following mathematical empirical formula has been proposed.

$$\sum h_1 = 0.001 - 0.0029Q_1 + 6.0486Q_1^2 \quad (26)$$

Expression (25) is obtained for the first arm (diameter $d=20$ mm, length $l=1.4m$) expresses the relationship between pressure drop in a pipe and flow.

In the second arm connected in parallel with the same approach (diameter $d=25$ mm, length $l=1.2m$) A mathematical empirical formula has been proposed proportional to the curve between pressure drop and flow in the pipe.

$$\sum h_2 = 0.0038 - 0.0583Q_2 + 1.472Q_2^2 \quad (27)$$

In the second arm connected in parallel with the same approach (diameter $d=32$ mm, length $l=1.0m$) A mathematical empirical formula has been proposed proportional to the curve between pressure drop and flow in the pipe.

$$\sum h_3 = 0.0052 - 0.0453Q_3 + 0.3171Q_3^2 \quad (28)$$

It should be noted that from the proposed mathematical empirical expressions, during the hydraulic analysis and design of simple pipelines, it is possible to calculate the value of the pressure drop at any value of the flow rate in the studied interval and select an energy source with optimal parameters. As is known, it is possible to establish the dependence between the pressure drop and the flow rate in parallel connected pipelines using the graph-analytical method. Based on the experimental and computational results, the following mathematical empirical expression was proposed in accordance with the dependence established between the pressure drop and the flow rate in parallel connected pipelines according to the research object.

$$\sum h = 0.0058 - 0.157Q + 0.1074Q^2 \quad (29)$$

This also allows you to run parallel using the given parameters. The flow rate in the individual branches of the connected pipes should be correctly calculated and the hydraulic system should be properly reported and designed.

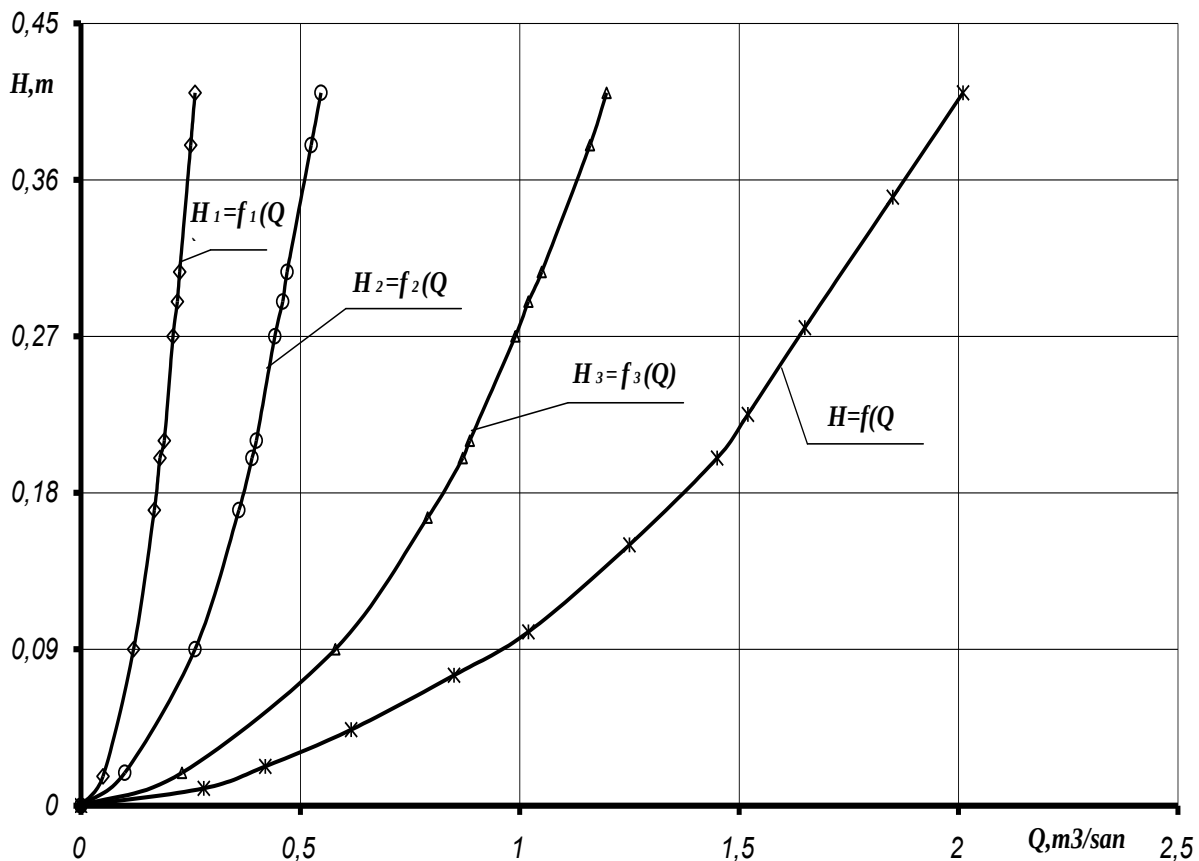


Figure 2. Dependence between pressure and flow in parallel connected pipes of different diameters and lengths

Results

1. Parallel The change in flow rate in separate branches at the same pressure loss values in connected plastic pipes of different diameters and lengths was experimentally investigated. $\sum h_1 = f(Q_1)$, $\sum h_2 = f(Q_2)$ and $\sum h_3 = f(Q_3)$ dependencies are established;

2. Based on the results of the experiment, separate parallel Mathematical empirical formulas have been proposed to calculate the pressure loss between the pressure drop and the flow in the combined branches at any value of flow.

3. Using the graph-analytical method, the flows in different branches at the same pressure loss values in parallel connected plastic pipes were collected and the dependence of the total flow on the pressure loss was established.

4. Taking into account the regularity of the constructed graphical dependence, a mathematical empirical formula was proposed to calculate the pressure loss in the studied interval depending on the flow.

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STUDY OF HYDRAULIC RESISTANCES IN CONTINUOUSLY JOINTED NON-METALLIC PIPES USED IN OIL FIELD EQUIPMENT

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Abstract

This article presents an experimental investigation into the hydraulic resistance encountered in series-connected pipelines of varying diameters and lengths, with a particular focus on plastic pipes commonly used in modern fluid transport systems. The main objective of the study is to examine the dependence of pressure drop on fluid flow rate, which is a critical factor in the design, efficiency, and reliability of pipeline networks used in industrial applications such as the transportation of oil and oil products.

To achieve this goal, the research began with a comprehensive review of the relevant scientific literature to understand the theoretical foundations of hydraulic resistance, flow dynamics, and pressure loss mechanisms in pipeline systems. Following the theoretical analysis, an experimental test rig was developed and implemented under laboratory conditions. The test setup was designed to simulate practical flow environments while enabling precise measurement of pressure drops across different segments of the pipeline system.

During the experiments, plastic pipes of three different internal diameters ($d_1 = 20$ mm, $d_2 = 25$ mm, $d_3 = 32$ mm) and corresponding lengths ($l_1 = 1.4$ m, $l_2 = 1.2$ m, $l_3 = 1.0$ m) were assembled in series to observe the cumulative effect of hydraulic resistance across a multi-section system. Flow rates were varied systematically, and pressure sensors were installed at key points along the pipeline to capture accurate data for each configuration.

The experimental findings revealed that the total hydraulic resistance in a series-connected pipe system is additive, meaning the overall pressure loss is equal to the sum of pressure losses across each individual section. This behavior was consistent across different pipe configurations and was influenced by factors such as pipe diameter, length, fluid velocity, and flow regime. Notably, smaller diameter pipes exhibited higher resistance due to increased frictional effects, while larger diameters demonstrated more efficient flow with reduced pressure drops.

The results obtained from the experiments were compared with classical hydraulic equations and models found in scientific literature, such as the Darcy-Weisbach equation, and showed good agreement with theoretical expectations. These findings are significant in the context of optimizing pipeline design for minimal energy consumption and accurate prediction of system behavior.

This research provides valuable insights for engineers, designers, and operators involved in fluid transport systems, supporting the selection of appropriate materials and pipe dimensions for efficient hydraulic performance. The study also lays a foundation for future work in optimizing flow in complex pipeline networks.

Keywords: hydraulic resistance, flow, pipelines, sequential connection, pressure

Introduction: The study of hydraulic resistances of sequentially connected pipes of different diameters and different lengths means establishing the dependence of the pressure drop on the flow rate. To establish this dependence, it is first necessary to assemble an experimental device. The data in the literature were analyzed to assemble the device. Then, experiments were conducted in laboratory conditions for the applied object, including the technical base of the laboratory, its hermeticity (first of all, it should not affect other scientific and technical research laboratories located in the vicinity).

The considered chapter of the dissertation work is devoted to the experimental study of hydraulic resistance in sequentially connected plastic pipes of different diameters ($d_1=20$ mm, $d_2=25$ mm, $d_3=32$ mm) and different lengths ($l_1=1.4$ m, $l_2=1.2$ m, $l_3=1.0$ m). As is known from the literature, scientific works have been carried out with a system for studying the hydraulic resistance of sequentially connected pipes. However, in connection with the development of science and technology, there is a need for experimental study of hydraulic resistance in pipes and fittings of different diameters and different

lengths produced as a result of new technological processes. Because, without being able to adjust the values of hydraulic resistances, the design of hydraulic machines would not be correct.

Suppose that simple pipelines (1,2,3) of different diameters and lengths are connected in series (Fig. 1 a). 4,5 and 6 are local resistances. It is known that since the fluid is incompressible, the flow rate will be the same at all points of such pipelines. The total pressure loss between points A and B is equal to the sum of the pressure losses in the individual pipes connected in series.

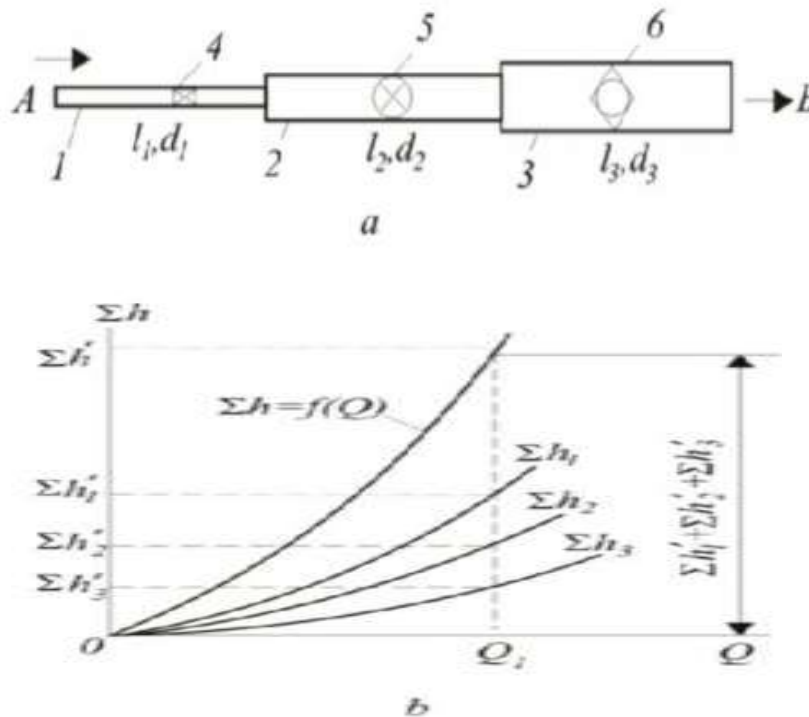


Figure 1. Joints of pipes of different lengths and different diameters

Methodology: The main purpose of this study is to study the hydraulic resistances in series-connected pipelines of different diameters and lengths, to determine the dependence of the pressure drop on the flow rate, and to evaluate the practical application possibilities of the obtained results. The research results are of great importance in terms of more efficient design of pipeline systems and optimization of hydraulic losses. During the study, the existing scientific literature was first analyzed, and then an experimental device was prepared and experiments were conducted in laboratory conditions. Plastic pipes of different diameters ($d_1=20$ mm, $d_2=25$ mm, $d_3=32$ mm) and different lengths ($l_1=1.4$ m, $l_2=1.2$ m, $l_3=1.0$ m) were used in the experiments. The flow rate was kept constant during the measurements, and the pressure loss in individual sections of the pipes was recorded and the total hydraulic resistance was determined. The results were compared with reliable literature sources and analyzed.

Experimental device

As is known, in order to conduct an experimental study of hydraulic resistances, experimental devices must meet the specific requirements intended for conducting experiments. For this purpose, first, safety regulations must be strictly observed in the experimental device, second, it must be convenient to change the pressure to establish the dependence of the hydraulic resistance - pressure drop on the flow in non-metallic pipes of different diameters and different lengths connected in series, third, there must be an opportunity to change the objects of research in the experimental device, fourth, the measuring devices placed in the experimental device must be located at such an optimal distance that it is possible to create a stationary regime. For this purpose, the initial distance in the laminar regime of movement is taken as $1.029d Re$, and for the turbulent regime of movement this distance is taken as $1.050d$.

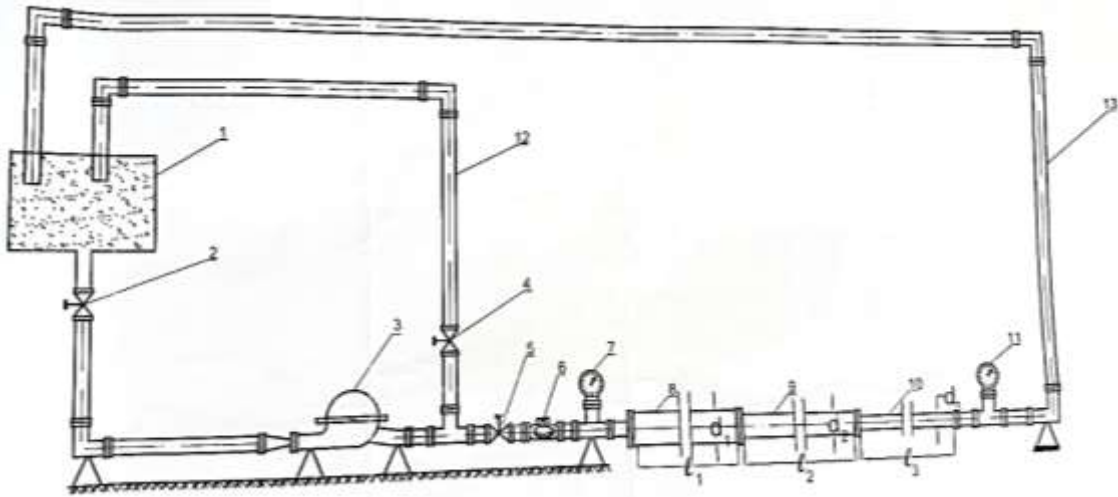


Figure 2. Experimental device for study of hydraulic resistances

Reporting methodology

As mentioned, the following issues are mainly encountered during the hydraulic calculation of pipelines:

1) Finding the diameter of the pipe when the flow rate, pressure difference, and length of the pipe are known;

2) Finding the pressure difference (at the starting and end points) when transporting the required flow through the pipeline (in this case, the diameter and length of the pipe are known);

3) Finding the fluid flow rate when the diameter and length of the pipeline and the pressure difference are known;

Analytical and graphoanalytical methods are used when conducting hydraulic reports of pipelines.

The simplest way to use the analytical method is to assume the flow regime to be laminar. This condition can be accepted in liquids with high viscosity and in cases where the ratio of the pressure difference to the length of the pipeline is not large.

If the viscosity of the fluid is low and the ratio of the pressure difference to the pipe length is large, then the motion regime is considered turbulent.

If the results of the inspection show that the adopted regime is incorrect, then the issue can be resolved using the graphoanalytic method.

The graphoanalytical method refers to the construction of the hydraulic characteristics of a pipeline.

The application of the graphoanalytic method both facilitates and simplifies the solution of the problem, and in some cases (for example, when studying the operation of several centrifugal pumps together with a pipeline) becomes the only way to solve the sought-after problem.

Hydraulic analysis of pipelines

Hydraulic analysis of pipelines is carried out to determine the geometric dimensions of the pipelines. Here, a certain flow rate of fluid, or the hydraulic characteristics of the pipeline, pressure loss and the flow rate of fluid passing through the cross section of the pipe are determined. All these calculations are carried out based on the known dimensions of the pipeline.

During the hydraulic analysis of pipelines in turbulent flow, the Bernoulli equation is used for two flow cross sections.

$$z_1 + \frac{p_1}{\rho g} + \alpha_1 \frac{v_1^2}{2g} = z_2 + \frac{p_2}{\rho g} + \alpha_2 \frac{v_2^2}{2g} + \sum h \quad (1)$$

here $\sum h$ It is the pressure loss between the sections 1-1 and 2-2. In general, the formula (Darcy) named after the first water pipe is used to determine this pressure loss between the sections under consideration.

$$\sum h = \frac{8gLv^2}{c^2 d 2g} = \lambda \frac{L}{d} \frac{v^2}{2g} \quad (2)$$

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here $\sum h$ It is the pressure loss between the sections 1-1 and 2-2. In general, the formula (Darcy) named after the first water pipe is used to determine this pressure loss between the sections under consideration.

$$\sum h = \frac{8gLg^2}{c^2 d 2g} = \lambda \frac{L}{d} \frac{g^2}{2g} \quad (4)$$

here λ - is the hydraulic resistance coefficient, which is determined as follows.

$$\lambda = \frac{8g}{c^2} \quad (5)$$

here c It is determined by the formula of Academician N.N. Pavlovsky. Then λ can be calculated as follows.

$$\lambda = \frac{8gn^2}{\left(\frac{d}{4}\right)^{2y}} \quad (6)$$

here n - is the pipe's roughness coefficient.

In formula (2) g when expressing its speed with the known formula, that is

$g = \frac{Q}{f}$, here Q - It is the flow rate of fluid passing through a pipe per unit time and is taken from experience.

$f = \frac{\pi d^2}{4}$ - is the area of the live cross-section of the pipe.

Then a new formula is obtained, which is called the second Sukemeri formula.

$$\sum h = \frac{LQ^2}{c^2 f^2 \frac{d}{4}} = \frac{64LQ^2}{c^2 \pi^2 d^5} = aL \frac{Q^2}{d^5} \quad (7)$$

$$\text{here } a = \frac{64}{c^2 \pi^2} = \frac{64n^2}{\pi^2 \left(\frac{d}{4}\right)^{2y}} \quad (8)$$

Given in diameter d for pipelines Q at the expense of $\frac{aQ^2}{d^5}$ is considered a constant quantity. That is,

$$\sum h = aL \frac{Q^2}{d^5} = AL \quad (9)$$

The fluid consumption in a determined movement is calculated using the following formula.

$$Q = fC\sqrt{RJ} \quad (10)$$

here J - is the hydraulic gradient and is the loss per unit length.

$$J = \frac{\sum h}{L}$$

R - Hydraulic radius is the ratio of the live cross-section to the wetted perimeter.

$$R = \frac{f}{\chi} = \frac{\pi d^2}{4\pi d} = \frac{d}{4} \quad (11)$$

From expression (8)
$$\frac{Q}{\sqrt{J}} = fC\sqrt{R} \quad (12)$$

For a pipe with a constant cross-section fC and R - is a constant quantity.

$$\frac{Q}{\sqrt{J}} = fC\sqrt{R} = K \quad (13)$$

here K - is a consumption characteristic.

$$K = fC\sqrt{R} \quad \text{or} \quad (14)$$

$$K = f\sqrt{\frac{2gd}{\lambda}} \quad (15)$$

Then
$$Q = K\sqrt{J} \quad (16)$$

If we express the flow characteristic in terms of diameter, then

$$K = fC\sqrt{R} = \frac{\pi d^2}{4} \sqrt{\frac{d}{4} \frac{1}{n}} R^y \quad (17)$$

Here, the strength indicator depends on the hydraulic radius and the coefficient of roughness according to the N.N.Pavlovsky formula. Studies have shown that among the existing empirical formulas, the formula of academician N.N.Pavlovsky is more correct in terms of its structure, i.e.

$$C = \frac{1}{n} R^y = \frac{1}{n} \left(\frac{d}{4}\right)^y \quad (18)$$

here n - is the roughness coefficient, characterizing the roughness of the pipe wall. For plastic pipes, $n=0.011$ was adopted. R - hydraulic radius; y - It is a variable strength indicator and is calculated as follows.

$$y = 2.5\sqrt{n} - 0.13 - 0.75\sqrt{R}(\sqrt{n} - 0.10) \quad (19)$$

As we mentioned, after experimentally studying the hydraulic resistance in sequentially connected pipes of different diameters and lengths, the total flow rate according to the flow meter reading was calculated using the following formula and is given in Table 2.

$$Q = \frac{V}{\tau} \quad (20)$$

here V - volume (amount) of fluid passing through the cross-section of the pipe, m^3 , τ - is the time for the liquid to flow, seconds.

table 1

Row No.	$Q \times 10^3$, m^3/sec	$P1$, kg/cm^2	$P2$, kg/cm^2	τ , s	$V \times 10^3$, m^3
1	0	0	0	0	0
2	0.65	0.015	0.24	46.15	3.0
3	0.8	0.019	0.027	37.5	-«-
4	1.1	0.023	0.027	27.23	-«-
5	1.2	0.027	0.032	25	-«-
6	1.3	0.032	0.036	23.7	-«-
7	1.45	0.037	0.036	20.6	-«-
8	1.5	0.041	0.044	20	-«-
9	1.65	0.047	0.044	18.1	-«-
10	1.705	0.054	0.048	17.54	-«-
11	1.75	0.059	0.048	17.14	-«-
12	1.82	0.062	0.048	16.5	-«-
13	1.96	0.066	0.052	15.3	-«-
14	2	0.071	0.052	15	-«-
15	2.045	0.074	0.056	14.67	-«-

The readings of the manometers $P1$, $P2$, are marked on the successively connected branches. Using the obtained experimental values, the pressure loss in the various branches can be calculated. For this purpose, knowing the value of Q obtained from the experiment according to the formula (17).

For a plastic pipe with a diameter of $d=20$ mm, we calculate $C1$ using formula (12), $C1=22.04$; Knowing that, we determine $K1$ from formula (11). $K1=0.48$ l/sec. Thus, we determine $C2$, $K2$ and $C3$, $K3$ in the same sequence. That is, $C2=24.02$; $K2=0.93$ l/sec; $C3=26.35$, $K3=1.89$ l/sec. Thus, the results obtained from the calculation based on experimental values are given in table 2.

table 2

Row No.	$\sum Q \times 10^{-3}, m^3 / san$	$H_1 m$	$H_2 m$	$H_3 m$
1	0	0	0	0
2	0.65	3.34	1.5	0.56
3	0.8	4.33	2.12	0.75
4	1.1	7.05	3.57	1.25
5	1.2	8.42	4.18	1.56
6	1.3	9.83	4.89	1.92
7	1.45	12.37	6.11	2.5
8	1.5	13.35	6.96	2.95
9	1.64	16.18	7.85	3.48
10	1.705	17.56	8.4	3.93
11	1.75	18.43	9.2	4.15
12	1.82	20.12	10.05	4.73
13	1.96	23.33	12.28	5.7
14	2	24.34	13.84	7.73
15	2.045	25.23	15.72	9.87

Conclusion

This study investigated the hydraulic resistance characteristics of continuously jointed non-metallic pipes commonly used in oil field equipment. Experimental results demonstrated that pressure loss in these pipelines is additive across series-connected sections and is strongly affected by pipe diameter, length, and surface conditions. Smaller diameter pipes produced higher frictional losses, while larger ones maintained more efficient flow. Despite minor turbulence introduced by jointing interfaces, the non-metallic pipes showed favorable hydraulic behavior, validating their suitability for oil transport applications.

The findings align well with classical hydraulic models such as the Darcy–Weisbach equation, confirming their applicability to modern polymer-based piping systems. Overall, the study highlights the potential of non-metallic pipes to enhance efficiency in oil field operations due to their low weight, corrosion resistance, and ease of installation. These results provide a useful foundation for further research on long-term performance and optimization of such systems under field-specific conditions.

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RESEARCH OF THE DEPENDENCES BETWEEN THE MAIN PARAMETERS OF A HYDROCYLINDER ENGINE OPERATING IN DIFFERENT LOAD MODES

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Abstract

This article studies the interdependencies between the main operating parameters of a hydraulic cylinder engine operating under different load conditions. Since hydraulic cylinders are widely used in technological processes and industrial facilities, their reliable and stable operation under changing external conditions is of particular importance. The main objective of the study in the article is to determine the effect of different load conditions on the engine performance - pressure, flow rate, output force and cylinder movement speed.

During the study, both theoretical analysis was carried out and the behavior of the engine under different conditions was modeled using simulation or experimental data. The functional relationships between the main parameters during the change of operating modes at different load levels were determined and their dynamic characteristics were analyzed. The results showed that an increase in load leads to an increase in pressure in the system, but after a certain level, the speed decreases and the efficiency weakens.

The research provides useful information for the design and optimal control of hydraulic cylinders. These results can be the basis for future energy efficiency improvements, system stability improvements, and effective operation of hydraulic systems applied in various industrial sectors.

Keywords: *hydraulic cylinder, load mode, pressure, flow rate, cylinder speed.*

INTRODUCTION: Hydraulic cylinders are important actuators widely used in modern industrial systems and mechanical engineering. They are used to achieve linear motion in various technological processes and occupy an important place in engineering systems due to their high output force, reliability and flexible control capabilities. The effective operation of hydraulic cylinders depends on the interaction of the main operating parameters such as pressure, flow and force occurring inside them. Especially under variable load conditions, these parameters change significantly, which affects the overall efficiency and energy consumption of the system.

Although many studies currently analyze hydraulic systems based on theoretical models, observations and measurements in real conditions - that is, on a practical device - provide more complete and reliable results. In this regard, studying the effect of different load regimes on the parameters of a real hydraulic cylinder engine allows us to form a more objective picture of the system's operation.

The aim of this article is to determine and evaluate the interdependencies between the main parameters – internal pressure, fluid flow rate, cylinder output force and movement speed – based on the results of research conducted on a real hydraulic cylinder unit under different load regimes. A special experimental device was designed for the study and real measurement data were collected under different load conditions by placing measuring instruments on it. The results obtained show that as the load increases, the internal pressure increases linearly, but after a certain limit, the flow stability is disturbed and the cylinder efficiency decreases.

The results of the study provide practical recommendations on the main criteria that should be considered when designing and operating hydro systems. This approach allows for both increased energy efficiency and long-term stable and sustainable operation of the system.

METHODOLOGY: The main objective of the study was to determine the functional dependencies between the main parameters of a real hydraulic cylinder engine operating under different load regimes - internal pressure, flow rate, cylinder output force and movement speed - and to assess the impact of these dependencies on the overall performance of the system. For this purpose, practical measurements were carried out based on the experimental method and the results were subjected to statistical and graphical analysis.

Classification and general information of hydraulic power cylinders: Hydraulic power reciprocating cylinders are used in most areas of technology, especially in construction, earthmoving, lifting transport, road vehicles, as well as in technological equipment such as metal cutting machines and press machines.

The main parts of a hydraulic cylinder are a cylindrical body with sealing elements and a piston rod (or plunger). In the case of a fixed body, the output point in hydraulic cylinders is the rod (plunger), and in the case of a fixed rod, it is the cylinder body.

Reciprocating hydraulic power cylinders can be classified as follows, depending on the elements included:

➤ by the number of effects:

- single-acting (unilateral) (figure 1.1)
- double-acting (bilateral) (figure 1.3)

➤ According to the construction of the dam in the body:

- piston
- plunger (figure 1.2)

➤ by the number of stocks:

- with one-sided stock
- with double-sided stock
- stockless;

➤ according to its construction:

- ordinary cylinders
- telescopic cylinders
- combined (mixed) type, etc.

The direction of movement of the rod depends on the cavity into which the working fluid enters. In this case, the working cavity of the cylinder on the opposite side is connected to the discharge line.

In single-acting hydraulic cylinders, the working travel of the piston occurs under the influence of the working fluid pressure, and the return to the initial position occurs under the influence of a spring or external forces R . Usually, hydraulic cylinders of this type are used when the required return force is small.

Plunger hydraulic cylinders have a single external main seal. Piston hydraulic cylinders have an internal (piston) seal.

In double-acting hydraulic cylinders, the piston moves forward and backward under the influence of fluid pressure.

In most cases, hydraulic cylinders operate under heavy, sudden (jumping) changes in load and speed, and in adverse climatic conditions. To prevent moisture and dirt from entering, a double dirt-collecting ring or other type of seal is used, and sometimes a rubber bellows that completely closes the rod during advancement.

The main indicators of hydraulic cylinders are:

- internal cylinder (piston) diameter D ;
- rod diameter d ;
- the force P generated at the outlet of the cylinder;
- the speed of the cylinder outlet v ;
- rod pitch (length of travel path) l ;
- working fluid consumption Q ;
- cylinder power N ;
- total η and mechanical η_{mex} of the cylinder, etc.
- Nominal pressure p_{nom} ;

In mechanical engineering and oil and gas hydraulic transfer devices, double-acting hydraulic cylinders with a single-sided rod are more widely used. In this type of hydraulic cylinder, the working movement of the rod and the forces acting on it can be in both directions. These cylinders have two working cavities (chambers).

The working fluid consumption (Q) is equal to:

$$Q = \omega u \quad (1.2)$$

The force P generated at the outlet of the cylinder:

$$P = \frac{F}{\omega} \quad (1.3)$$

F – working area of the piston,
Cylinder power N ;

$$N = Fu \text{ or } N = PQ \quad (1.4)$$

The step of the rod (length of the travel path) l ;

$$l = G\omega \quad (1.5)$$

The speed of the cylinder outlet is v ;

$$v = \frac{Q}{\omega} \quad (1.6)$$

where Q – the flow rate of the working fluid entering the hydraulic cylinder, ω – working area of the piston

Hydrocylinder, like other large-volume hydraulic machines, The total FIA is defined by the following expression: η_s

$$\eta_{etc} = \eta_{pilgrimage} \eta_{mech} \eta_h \quad (1.7)$$

Here hydraulic cylinder η_{hajj} – volume, η_{mex} – mechanical, η_h – hydraulic FIA.
 ω_1 and – working areas of pistons; ω_2

$$\omega_1 = \frac{\pi D^2}{4}; \quad (1.8) \quad \omega_2 = \frac{\pi (D^2 - d^2)}{4}$$

where D is the diameter of the cylinder (piston), d – is the diameter of the plunger.

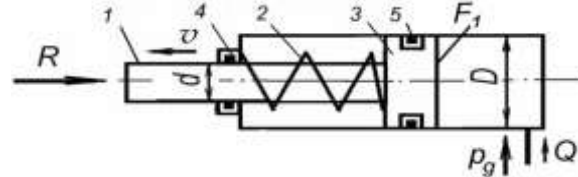


Figure 1.1. Diagram of a single-acting, single-acting rod hydraulic cylinder
1 – stock; 2 – spring; 3 – piston; 4 – stock sealer;
5 – piston seal

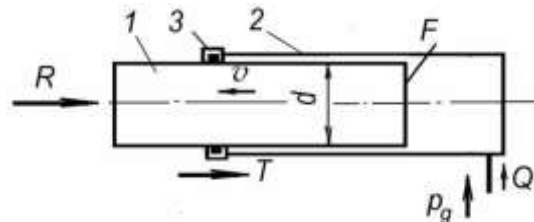


Figure 1.2. Diagram of a plunger hydraulic cylinder
1 – plunger; 2 – cylinder body; 3 – plunger seal

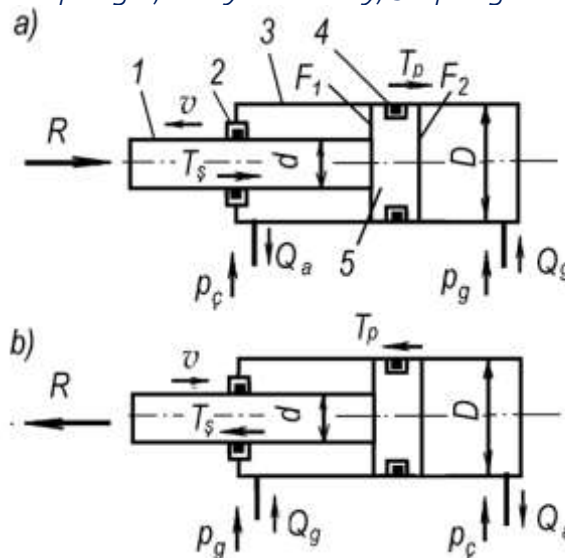


Figure 1.3. Scheme of forward and reverse movements of a double-acting single-acting rod hydraulic cylinder

1 – rod; 2 – rod seal; 3 – cylinder body;
4 – piston sealer; 5 – piston

Constructions of hydraulic power cylinders: Power hydraulic cylinders are manufactured in industry from seamless steel tubes with normal accuracy, hot and cold drawn. Power cylinders are usually designed as assemblies. They consist of a body, piston, rod, seals and caps.

The covers of hydraulic cylinders are usually made flat and are connected to the body by threads or bolts. The back cover without holes (on the piston cavity side) is often welded to the body. The supply and discharge of working fluid to hydraulic cylinders is carried out through fittings connected to the body by threads.

The body of the hydraulic cylinder consists of a flange welded to a cylindrical tube (sleeve), a hinged cover and a perforated cover. Inside the body, a piston is placed, fastened with a nut together with cuffs. The rod passes through the perforated cover and is sealed with a piston by a sealing ring. The cover is sealed with a ring by the cylinder body. The rod is sealed at the outlet by a cuff, ring and debris cleaning ring 4. The hangers are equipped with articulated bearings.

To lower the beam, the working fluid is supplied to the cavity on the piston side of the cylinder, and to raise it, to the cavity on the rod side, meaning that only the tensile force acts on the rod during lifting.

Hydraulic power cylinders often rotate to some angle during operation. In order to keep the supply and discharge pipes from the feed pump and cylinder stationary, the cylinders can be fixed with hinges (joints). In this case, the supply and discharge of the working fluid is carried out through hinged sleeves connected to the cylinder body of the machine. In this design, the working fluid is transmitted to the sleeves through rigid rigid pipes, and then through channels in the swinging cylinder through holes, respectively, into the piston or rod cavities.

In order to simplify the design of swinging power cylinders in oilfield mobile hydraulic units, it is more convenient to supply and discharge the working fluid through the cylinder rod.

This hydraulic power cylinder has channels placed in the head of the hollow rod. The working fluid passes through the channel and tube and enters the piston cavity of the cylinder, and at this time, the working fluid is discharged from the rod cavity of the cylinder through the internal channel and hole of the channel rod. In this type of construction, the connection of the cylinder to the hydraulic system is simplified and its reliability increases.

The sequence of calculation of hydraulic power cylinders:

The calculation of hydraulic power cylinders is carried out in the following sequence:

- 1) The maximum dimensions of the hydraulic power cylinder are determined depending on its location in the device;
- 2) determination of the useful (external) load R acting on the rod of the hydraulic power cylinder and on it in the axial direction;
- 3) The necessary force P_p generated by the hydraulic cylinder is calculated to overcome the useful load acting on the rod in both directions of movement;
- 4) the scheme of the hydraulic power cylinder and the method of attachment to the device are adopted;
- 5) determination of the rod pitch l ;
- 6) The pressure of the working fluid in the cylinder is assumed to be p_g ;
- 7) Taking into account the pressure of the working fluid in the cylinder and the forces created during operation with the hydraulic cylinder, the working area F of the cylinder piston is found;
- 8) The diameters of the cylinder piston D and the rod d are calculated and adjusted according to the values in standards and industry norms (usually, $d = (0.5 \dots 0.7)D$ is accepted;

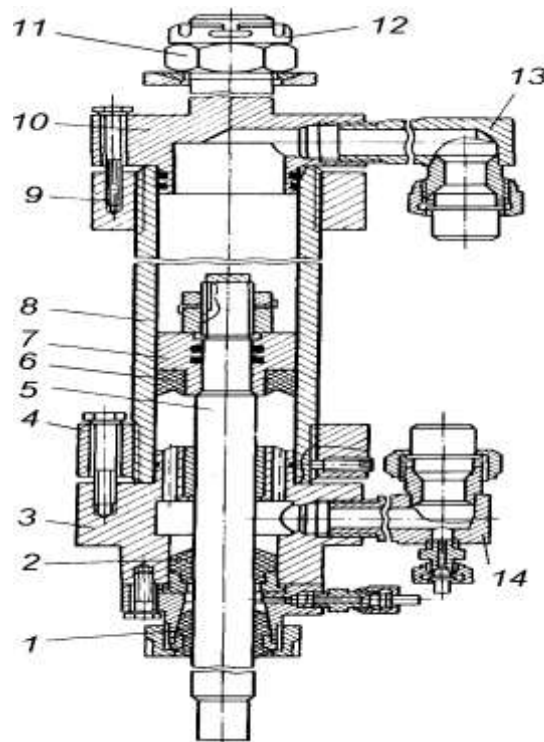


Figure 1.4. Single-acting hydraulic cylinder with a single-acting rod of a unified rod pump unit.

1 – dirt collecting (protective) gasket; 2 – stem gasket; 3 – lower cover;
4, 9 – flanges; 5 – stock; 6 – piston valve; 7 – piston; 8 – cylinder body
(cylinder); 10 – top cover; 11 – nut; 12 – lock nut; 13, 14 – fittings.

Conclusion

The conducted research highlights the complex interdependencies between pressure, flow rate, output force, and movement speed in a hydraulic cylinder engine under varying load conditions. Both theoretical analysis and simulation data confirmed that increasing the external load results in higher system pressure; however, beyond a certain threshold, this also leads to a reduction in movement speed and overall efficiency.

These findings emphasize the need for careful consideration of load conditions in the design and operation of hydraulic systems. Understanding the dynamic behavior of key parameters allows engineers to predict performance more accurately and implement control strategies that enhance system stability and energy efficiency.

The results of this study provide a valuable foundation for the development of more efficient hydraulic drives, enabling their optimized application across various industrial sectors. Future work may focus on real-time adaptive control systems that respond dynamically to load variations, further improving the performance and reliability of hydraulic machinery.

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STUDY OF THE EFFECT OF VOLCANO ASH ON THE PROPERTIES OF CEMENT-BASED DRY CONSTRUCTION MIXTURES

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Abstract

The present study investigates the influence of volcanic ash on the properties of dry construction mixtures. It was determined that as the amount of volcanic ash used instead of quartz sand increases, the setting time of the mixtures is prolonged, their plasticity improves, and a certain decrease in the density of the mortar is observed. The noticeable reduction in density is mainly explained by the dispersed composition of volcanic ash and the consequently higher water demand for achieving normal consistency. It was established that replacing up to 15% of quartz sand in cement-based construction mortar with volcanic ash enhances the adhesion of the mortar to various surfaces (ceramics, concrete, limestone) and increases its sorption moisture after hardening. These findings indicate that the studied compositions possess high hygienic and consumer properties as a new generation of dry construction mixtures, which allows their application in areas characterized by specific humidity conditions such as basements, attics, and bathrooms.

Keywords: Volcanic ash, sorption moisture, dry construction mixture, pozzolanic additive, Portland cement, quartz sand

The application of dry construction mixtures (DCMs) in construction and finishing works is expanding year by year. Compared to traditional mortars that are typically prepared directly at construction sites, the advantage of these materials lies in the fact that they are delivered to the site in a ready-made, pre-packaged form according to the required composition and properties, and are used simply by mixing with water. Centralized production ensures the stable composition of these mixtures, including a consistent granulometric structure and stable properties, thereby improving the overall quality of construction works [1].

In the production of dry construction mixtures, depending on their intended use, traditional hydraulic and air-setting binders (Portland cement, gypsum, lime, etc.), quartz sand with a specific granulometric composition, and various functional additives are used. These functional additives ensure the optimal rheological and high performance-technical characteristics of the mortars [2–3].

In recent years, the dry construction mixtures market has been rapidly developing both globally and in our country. However, our research indicates that the product range of most enterprises is represented by similar types, and there is a lack of new approaches and proposals aimed at meeting the growing aesthetic and sanitary-hygienic demands of consumers. We believe that the development, characterization, and application of a new generation of dry construction mixtures is a crucial and current scientific-practical issue, particularly for maintaining sanitary-hygienic conditions within acceptable standards in areas typically characterized by high humidity, such as sanitary units, and to some extent, kitchens, balconies, basements, and attics.

It is well known that under high humidity conditions, plasters, wallpapers, decorative gypsum elements, furniture, various items, devices, and accessories tend to deteriorate rapidly, leading to a decline in their aesthetic and artistic qualities. Furthermore, a humid environment creates favorable conditions for the formation and proliferation of mold and bacteria on walls and between finishing materials. This results in the emergence of various unpleasant odors and adversely affects the health of occupants. Therefore, this new class of dry construction mixtures must retain their functionality under humid conditions while also possessing anti-mold and antibacterial properties.

It is well known that pozzolanic additives are widely used to enhance the hardening properties of materials under humid conditions and to improve their performance characteristics in such environments. Pozzolans are employed as hydraulic additives that provide air lime with the ability to harden in moist conditions and as binders for the free lime released during the hydration of Portland cement. Since ancient times, dehydrated clay (clay calcined at 500–700°C) and volcanic ashes have been widely used as pozzolanic additives. In recent years, the use of metakaolin for this purpose has also become increasingly widespread.

Thus, this study investigates the feasibility of using volcanic ash as a mineral-active pozzolanic additive for the development of a new generation of dry construction mixtures with complex performance and hygienic properties. The volcanic ash used in the study was sourced from the Ceyranchol region in Azerbaijan, which is known for its large reserves of such material.

It is well known that mineral active additives react with CaO released during the hydration of Portland cement, regulating the composition of hydration products and thereby enhancing the durability of the material [4–14]. When pozzolanic cements harden, the cement particles first interact with water to form calcium hydroxide, dicalcium hydrosilicate (C_2SH_2), and highly basic calcium hydroaluminates and hydroferrites. The presence of an active mineral additive accelerates the hydration and hydrolysis of the cement component in the pozzolanic cement. Subsequently, the active components of the additive react with the hydration products of the cement, primarily with calcium hydroxide. This gradually reduces the concentration of lime in the liquid phase of the hardening system, resulting in the transformation of dicalcium hydrosilicate into monocalcium silicate – CSH(B), and of highly basic hydroaluminates into less basic forms. When hydroaluminates interact with active SiO_2 , they form sulfate-resistant hydrogarnets of the type $3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2 \cdot (6-2x)\text{H}_2\text{O}$.

Pozzolanic cements, in which calcium hydroxide is bound and less basic hydrosilicates and hydroaluminates of calcium are formed compared to ordinary cement, show higher resistance to leaching with fresh water and to the effects of mineralized waters. When interacting with calcium hydroxide and water during cement hydration, individual fine grains of the pozzolanic additive swell in volume. This causes compaction of the mortar or concrete. Such densification enhances the water and salt resistance of pozzolanic cement by making it more difficult for aggressive water to penetrate the concrete matrix, thereby preventing structural deterioration.

It is also worth noting that pozzolanic particles in a highly dispersed state possess numerous active acidic centers on their surface, which are responsible for both their high hygroscopicity and their intensive interaction with free CaO [4–15]. For this reason, pozzolanic additive systems also participate in moisture regulation by adsorbing the water required for hydration processes from the humid environment.

Methodology of the experiments: Since the activity of the additive determines its optimal usage rate, the activity of the Ceyranchol volcanic ash was initially assessed using the lime absorption method from a known lime solution [16]. The activity of the volcanic ash was found to be 75 mg CaO/g. The chemical composition of the volcanic ash and the hardened construction mixture was determined using the S8 TIGER spectrometer (Bruker, Germany) (Table 1), while the mineralogical composition was studied using the Miniflex 600 X-ray diffractometer (Rigaku, Japan) with a copper anode (Figure 1, Table 2). According to the results of the X-ray phase analysis, the mineral composition of the Jeyranchol volcanic ash used in the study consists mainly of active glass phase (74%), feldspar (12%), and quartz (11%). The high content of glass phase indicates the high reactivity of the volcanic ash.

Table 1.

Mineralogical composition of volcanic ash

Ceyranchol volcanic ash	Mineralogical composition of volcanic ash, mass %				
	Quartz	Feldspar	Hematite	Volcano glass	Total
	11	12	3	74	100

Table 2

Chemical composition of volcanic ash

Ceyranchol volcanic ash	Chemical composition of volcanic ash, mass %							
	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	FeO	Total
	3,67	1,05	13,91	71,86	3,93	2,33	3,25	100

It is well known that the required amount of pozzolanic additives in pozzolanic cements depends on their reactivity. However, using large quantities of low-reactivity pozzolans in compositions is not advisable, as a significant portion of such additives would act merely as inert filler (ballast) [15]. During the experiments, certain proportions of Ceyranchol volcanic ash, used as a replacement for quartz sand,

were investigated in terms of their effects on the technological and mechanical properties of construction mortars.

Discussion of research results: To determine the optimal content of volcanic ash in dry mixtures, finely dispersed volcanic ash was added at levels of 5%, 10%, 15%, and 20% in place of quartz sand to a standard Portland cement-based dry mixture (Portland cement 42.5 MPa, produced by Qaradağ Holcim cement plant – 40%, quartz sand – 59%, polymer additive – 0.8%, and cellulose additive – 0.2%). In our experiments, the volcanic ash used had a residue of no more than 15% on the 0.8 mm sieve. X-ray phase analysis of the hydration products was carried out, and the amount of free CaO was determined. The results of the analysis showed that replacing quartz sand with volcanic ash above the 10–15% range is not recommended. Beyond this interval, no significant decrease in the amount of free CaO was observed. Additionally, the granulometric composition of the system becomes disrupted, which negatively affects the mechanical properties of the hardened coating (Tables 3 and 4) [17–19].

Table 3.

Technological properties of dry construction mixtures containing volcanic ash

Portland cement, %	Quartz sand, %	Volcanic ash, %	Normal density, %	Holding time, hours		Plasticity, cm	Density of the solution, kg/m ³
				Start, min	Last, hour		
40	59	-	27	40	8	8	1800
40	54	5	28	45	9	8	1795
40	49	10	30	52	10	9	1790
40	44	15	31	60	11	9	1780
40	39	20	34	65	13	9	1775

Table 4

Strength of construction mortars based on dry construction mixtures containing volcanic ash (on a dense structural base).

Portland cement, %	Quartz sand, %	Volcanic ash, %	The amount of CaO in the 7-day hydration product, %	Bending strength limit, MPa			Compressive strength limit, MPa		
				7 day	14 day	28 day	7 day	14 day	28 day
40	59	-	5,4	0,81	1,40	1,52	8,2	10,8	14,5
40	54	5	4,1	0,72	1,38	1,50	8,0	10,2	13,9
40	49	10	2,2	0,67	1,35	1,47	7,8	10,3	14,2
40	44	15	1,1	0,65	1,33	1,53	7,1	10,2	14,2
40	39	20	1,1	0,65	1,30	1,52	6,0	10,2	13,6

As seen from Table 3, when volcanic ash is used as a replacement for quartz sand, an increase in its amount leads to an extension in the setting time of the mixtures, an increase in plasticity, and a certain reduction in the density of the mortar. This aligns with existing theoretical conclusions. The noticeable decrease in the density of the mortar is mainly attributed to the dispersion characteristics of the volcanic ash, which results in a higher water demand for achieving normal consistency.

When quartz sand is replaced by volcanic ash, a reduction in both flexural and compressive strength is observed. However, the decline is not significant and reaches up to 20% primarily in the early stages of hardening. At 28 days of curing, the strength of compositions containing volcanic ash is almost identical to the mechanical properties of the reference (ash-free) composition; in some experiments, a slight increase was even recorded. This tendency is typical for pozzolanic systems [4–16].

The slight variation in strength during the early days of hardening is explained by the fact that the mineral formation processes that determine hardening are not yet complete. We assume that at 7 days of curing, the hydration of cement minerals is still in its initial phase, the formation of hydrosilicates is ongoing, and simultaneously, the reaction between the free CaO released during hydration and the active glassy phase of the pozzolan is still in progress.

The performance characteristics of construction mortars are determined not only by their mineralogical and granulometric compositions and the water-to-binder ratio, but also by the nature of the substrate they are applied to. Surface texture, chemical nature, and porosity are the main factors influencing the adhesion and mechanical performance of mortars. In the next stage of our research, the effect of volcanic ash on the adhesion of construction mortars to surfaces of different chemical nature (concrete, ceramic, limestone) was studied (Table 5) [17].

Table 5

Adhesion of construction mortars with volcanic ash additives to bases of various natures after hardening in dry weather for 28 days, MPa

Portland cement, %	Quartz sand, %	Volcanic ash, %	Adhesion, MPa								
			Concrete base			Ceramic brick base			Saw stone		
			7 day	14 day	28 day	7 day	14 day	28 day	7 day	14 day	28 day
40	59	-	1,3	1,4	2,2	1,5	2,1	2,8	1,4	1,9	2,6
40	54	5	1,4	1,5	2,4	1,6	2,2	3,2	15,3	2,0	3,0
40	49	10	1,6	1,8	2,7	1,8	2,7	3,4	15,2	2,5	3,2
40	44	15	1,7	2,2	2,8	2,1	2,9	3,6	15,1	2,8	3,4
40	39	20	1,6	2,2	2,7	2,1	2,8	3,3	14,7	2,8	3,1

As seen from Table 5, increasing the amount of volcanic ash improves the adhesion of the construction mortar. This is explained by both the fine dispersion composition (mainly <0.08 mm) and the high activity of the mineral volcanic ash additive, which replaces the coarse-grained quartz sand (main fraction 0.1–0.63 mm). The fine dispersive structure increases the contact surface between the base and the adhesive mortar, facilitates the penetration of dispersed particles into the substrate, and consequently enhances the base–adhesive bond strength. Higher adhesion was observed on clay brick and limestone surfaces, which can be attributed to their porosity and chemical nature. In contrast, the penetration of mortar into dense concrete surfaces is lower, which results in reduced adhesion performance.

As noted above, one of the primary goals of the study is to develop dry construction mixtures that can operate effectively under high humidity conditions by utilizing the specific properties of pozzolanic additives. The efficiency of the studied construction mortars under humid conditions was evaluated by examining their sorption moisture capacity in accordance with **GOST 24816-81** [19-20].

Table 6

Sorption moisture of hardened construction mortars

Portland cement, %	Quartz sand, %	Volcanic ash, %	Sorption moisture at 90% relative humidity, %
40	59	-	1,5
40	54	5	2,5
40	49	10	2,8
40	44	15	3,2
40	39	20	3,4

As shown in Table 6, increasing the amount of volcanic ash in the mixture significantly increases the sorption moisture capacity (more than threefold). This indicates that the studied compositions possess high hygienic and consumer properties as next-generation dry construction mixtures. Consequently, they are suitable for application in areas characterized by specific humidity conditions, such as basements, attics, and bathrooms.

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EVALUATION OF MAGNETIC SEPARATION EFFICIENCY FOR INCREASING IRON CONTENT IN TITANOMAGNETITE ORES OF THE TYMLAISKY DEPOSIT

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Abstract

This study investigates the feasibility of effective dry magnetic separation for titanomagnetite ores with a particle size of 1 mm as an alternative to conventional wet separation for particles of 0.075 mm. The objectives are to reduce grinding costs and water consumption, as well as to minimize titanium and vanadium losses and concentrate contamination by gangue, which is especially important in the beneficiation of finely disseminated titanomagnetite ore.

It was established that the iron recovery to the magnetic fraction is 87.39%, and the increase in iron content to 52.34% compared to 38.98% in the non-magnetic fraction confirms the efficiency of dry magnetic separation.

The results obtained will be used to develop a general technological concept for processing of titanomagnetite ores of Tymlayskoye deposit (Kazakhstan).

Keywords: *titanomagnetite ores, ilmenite, magnetic separation, Tymlai deposit, recovery, concentrate*

Introduction. Based on the study of the technological properties of titanomagnetite ores, it has been established that these ores cannot be separated using physical methods [1–3].

The titanomagnetite ores of the Tymlay deposit are a promising source of iron, titanium, and vanadium. However, their finely disseminated nature and the presence of gangue minerals pose certain challenges for beneficiation.

The most common technology for extracting valuable components is wet magnetic separation, which requires grinding the ore to a particle size of 0.075 mm. This results in high energy and water consumption [4–5].

The relevance of this study lies in exploring the possibility of using dry magnetic separation for particles sized up to 1 mm. This could help minimize grinding costs and reduce water consumption. In addition, this approach may contribute to lower losses of valuable components in tailings and improve the quality of the concentrate.

The aim of this research is to evaluate the efficiency of dry magnetic separation of titanomagnetite ores with a particle size of 1 mm in comparison with wet separation.

Research Methods. The object of the study is the titanomagnetite ore from the Tymlay deposit (Kazakhstan).

The ore sample was a core with a height of 12–15 cm and a diameter of 5 cm (Figure 1).



Fig. 1. Cores of titanomagnetite ores of Tymlai deposits

For magnetic separation, 3.5 kg of ore was prepared, subjected to two-stage crushing to a particle size not exceeding 1 mm.

Dry magnetic separation of titanomagnetite ore from the Tymlai deposit after preliminary crushing was carried out according to the technological flowchart shown in Figure 2.

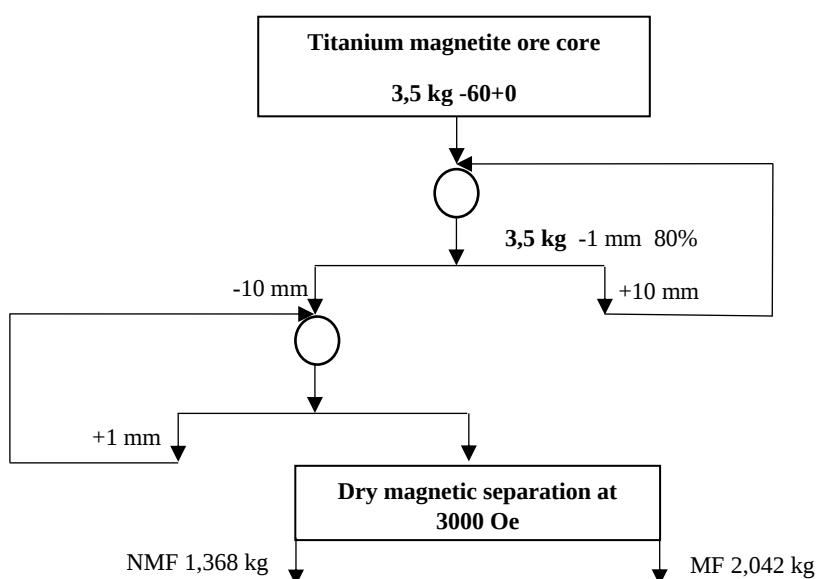


Fig. 2. Process flow diagram for core processing of titanomagnetite ores by dry magnetic separation.
Evaluation of Results.

Table 1. Separation results of magnetic and non-magnetic fractions

Initial phase.																
bal	Fe	Si	Mg	Ti	Ca	Al	P	Mn	K	Zn	S	Cl	V	Cr	Ba	others
52.59	24.38	8.697	2.17	3.23	4.85	1.69	1.15	0.324	0.285	0.128	0.199	0.084	0.078	0.052	0.036	0.077
	52.37	18.66	4.66	6.94	10.42	3.63	2.47	0.7	0.61	0.27	0.43	0.18	0.17	0.11	0.08	0.17
Non-metallic phase																
bal	Fe	Si	Mg	Ti	Ca	Al	P	Mn	K	Zn	S	Cl	V	Cr	Ba	others
52.85	20.34	9.85	4.6	2.16	5.69	1.91	1.32	0.321	0.370	0.081	0.212	0.060	0.060	0.047	0.046	0.086
	38.98	18.88	8.81	4.14	10.91	3.66	2.53	0.62	0.71	0.16	0.41	0.11	0.11	0.09	0.09	0.16
Metallic phase																
bal	Fe	Si	Mg	Ti	Ca	Al	P	Mn	K	Zn	S	Cl	V	Cr	Ba	others
42.79	29.53	10.04	5.41	4.70	2.79	2.52	0.746	0.317	0.305	0.206	0.211	0.140	0.114	0.065	0.038	0.084
	52.34	17.80	9.59	8.33	4.95	4.47	1.32	0.56	0.54	0.37	0.37	0.25	0.20	0.12	0.07	0.15

As seen in Table 1, a high degree of iron recovery (87.39%) is observed in the magnetic fraction.

The increase in iron content in the magnetic fraction to 52.34% (compared to 38.98% in the non-magnetic fraction) confirms the effectiveness of the magnetic separation. However, a portion of iron (12.61%) remains in the non-magnetic fraction, which may be related to the finely disseminated nature of the ore. To increase iron recovery, repeated magnetic separation with adjusted magnetic field parameters may be applied.

The increase in titanium content in the magnetic fraction (up to 8.33%) compared to the non-magnetic fraction (4.14%) indicates its partial association with magnetic minerals. The high titanium recovery (93.34%) combined with its increased concentration in the magnetic fraction makes the separation process promising for further processing.

The content of phosphorus (P) and sulfur (S) in the magnetic fraction decreases compared to the initial ore. This is a positive result since phosphorus and sulfur are undesirable impurities in ferrous metallurgy, especially considering that the obtained concentrate is planned for use in direct steel production alloyed with titanium and vanadium [6–7].

Conclusions. Dry magnetic separation of ores with a particle size of 1 mm effectively recovers iron and titanium with minimal losses, confirming the promising potential of this method for the preliminary beneficiation of finely disseminated titanomagnetite ores from the Tymlay deposit.

Despite challenges caused by fine grain size and gangue minerals, dry separation reduces grinding and water consumption.

The developed approach allows obtaining a concentrate suitable for further processing and represents an economically efficient alternative to traditional wet separation methods.

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