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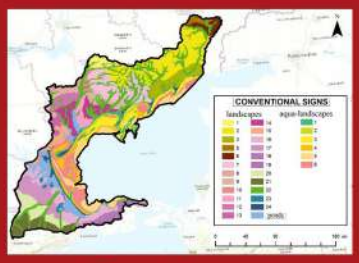

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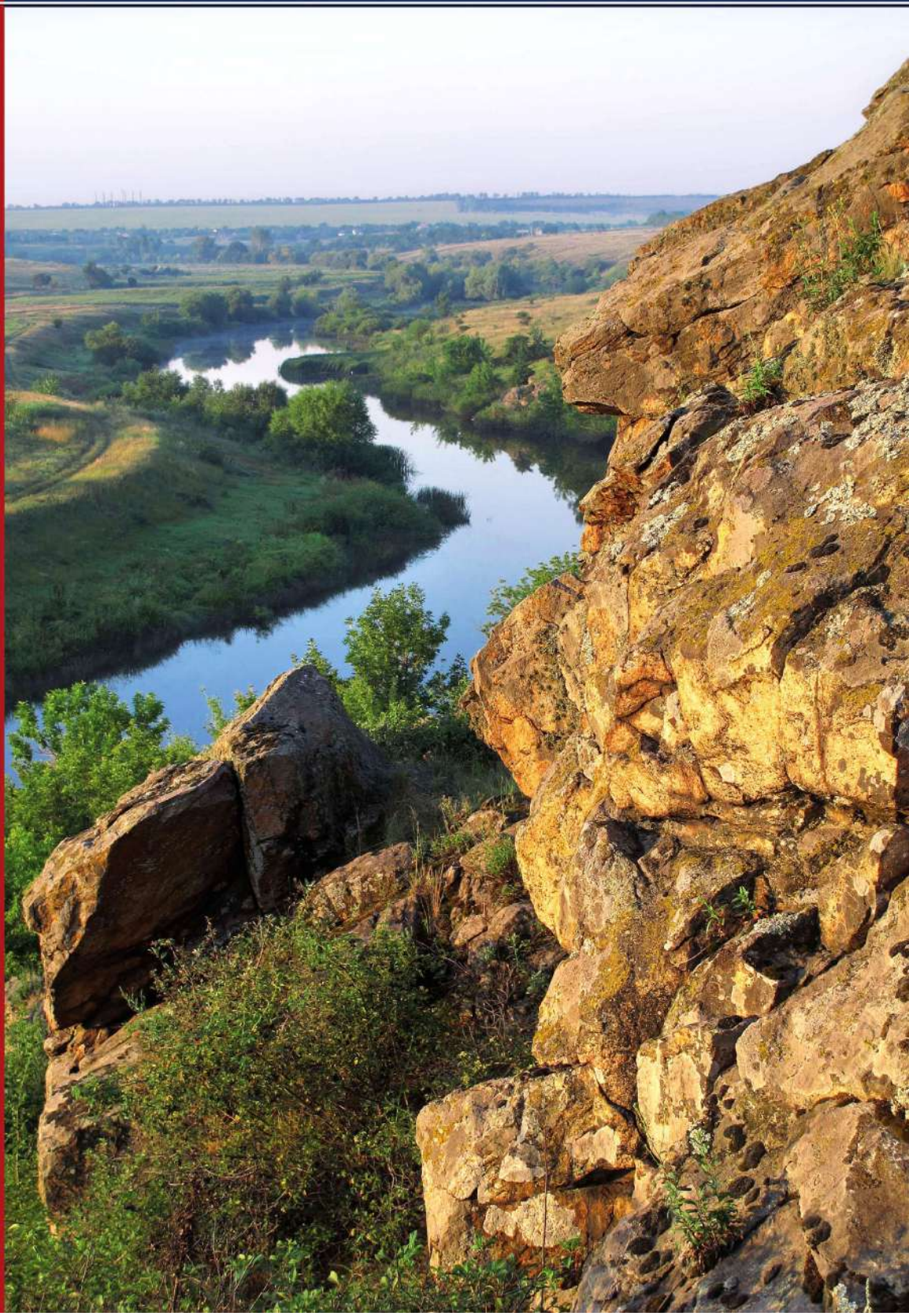

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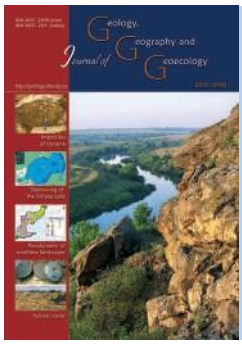

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Marketing mechanisms of tourist industry development in an unstable environment

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Abstract. The development of the tourism industry must take into account the peculiarities of the modern economic space, which is constantly changing and has many negative factors. Such an unstable environment is characterized by an uneven relationship and interdependent factors that affect the creation and consumption of the tourism product and create the multidimensionality of the tourist services market. On the basis of studying the mobility and variability of environmental factors as the modern information cooperation between producers and consumers in the tourist services market, we address the problem of implementing marketing mechanisms and their influence on the formation of consumer demand for tourist services. The use of marketing approaches and the mechanism of their implementation, the creation of a modern marketing environment will add stability in the market of tourist services and enhance its competitiveness. It is a question of changing the conceptual model of setting the problem of development of the tourist services market, which should be based on the totality of beliefs, values that are consumer oriented, the system of communication with specific people; finding effective ways to transform the perception of the customer's expectations into the criteria for the desired quality of the tourism product, etc. An effective marketing strategy in the market of tourist services is possible provided that the mechanisms of influence of marketing instruments on the work of the tourism enterprise are explored in the conditions of an unstable environment, taking into account communicative and social methods of increasing the effectiveness of marketing activity in the market of tourist services. It is marketing that allows you to study and analyze the market as an object that is constantly evolving and changing under the influence of human activity. The marketing mechanisms identified by the authors in the context of environmental stabilization (research on consumer motivation and psychology, creation of new types of tourism product, involvement of employees in the formation of marketing policy of the enterprise, public-private partnership, development of creative industries, etc.) imply the recognition of culture as an instrument for the development of regional cultural industries, which implies the formation of a market for tourist services, taking into account the opportunities of the region and its cultural characteristics. The choice of the region is explained by the fact that the characteristic feature of Kryvyi Rih is the excessive technological load, its pollution under the influence of the activities of mining, metallurgical and other industrial enterprises and therefore the search for ways to overcome the environmental crisis.We analyze the possibilities of the Kryvyi Rih region from the point of view of forming the promotional environment through the cultural policy of the region, promotion of the brand of the city, formation of its image. Potential development opportunities in the industrial tourism industry have been identified. The theoretical and methodological basis of the research is provided by the position of modern economic theory, management theory, psychology of communications, works of domestic and foreign specialists in the field of tourism marketing. The research work uses methods that provide its logical essence – the dialectical method of scientific knowledge, the method of system-structural analysis, the method of modeling complex systems.

Keywords: tourism industry, tourist services market, marketing mechanisms, cultural industry, unstable environment,unconventional tourist product, industrial tourism

Маркетингові механізми розвитку індустрії туризму в умовах нестабільного середовища

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Анотація. Розвиток індустрії туризму повинен передбачати врахування особливостей сучасного економічного простору, який постійно змінюється і має багато негативних чинників. Таке нестабільне середовище характеризується нерівномірністю взаємозв'язків та взаємообумовлених факторів, які впливають на процес утворення та споживання туристичного продукту й утворюють багатовимірність ринку туристичних послуг. На основі вивчення рухливості й змінності чинників середовища

як сучасного інформаційного співробітництва між виробниками та споживачами на ринку туристичних послуг набуває актуальності проблема реалізації маркетингових механізмів та їх впливу на формування попиту споживачів туристичних послуг. Використання маркетингових підходів та механізму їх реалізації, створення сучасного маркетингового середовища додасть стабільності на ринку туристичних послуг та підсилить його конкурентоспроможність. Мова йде про зміну концептуальної моделі постановки проблеми розвитку ринку туристичних послуг, яка повинна ґрунтуватися на врахуванні сукупності переконань, цінностей, які повинні бути зорієнтовані на споживача, систему комунікацій з конкретними людьми; пошук ефективних методів перетворення сприйняття суб'єктом туристичної діяльності очікувань клієнтів в критерії бажаної якості туристичного продукту тощо. Ефективна маркетингова стратегія на ринку туристичних послуг можлива за умови дослідження механізмів впливу інструментарію маркетингу на роботу туристичного підприємства в умовах нестабільного середовища, врахування комунікативних і соціальних прийомів підвищення ефективності маркетингової діяльності на ринку туристичних послуг. Саме маркетинг дозволяє вивчати і аналізувати ринок як об'єкт, який постійно формується та змінюється під впливом діяльності людини. Маркетингові механізми визначені авторами у контексті стабілізації середовища (дослідження мотивації і психології споживачів, створення нових видів турпродукту, залучення працівників до формування маркетингової політики підприємства, приватно-громадське партнерство, розвиток креативних індустрій та ін.) передбачають визнання культури як інструменту розвитку регіональних культурних індустрій, що передбачає формування ринку туристичних послуг з урахуванням можливостей регіону та культурних його характеристик. Вибір регіону пояснюється тим, що характерною рисою Криворіжжя є надмірне технологічне навантаження, його забруднення під впливом діяльності підприємств гірничодобувної, металургійної та ін. промисловості, а отже пошук шляхів подолання екологічної кризи. Проаналізовані можливості Криворізького регіону з точки зору формування середовища заохочення шляхом культурної політики регіону, просування бренду міста, формування його іміджу. Визначені потенційні можливості розвитку в регіоні туризму індустріального спрямування. Теоретико-методологічною основою дослідження є положення сучасної економічної теорії, теорії управління, психології комунікацій, наукові праці вітчизняних та зарубіжних учених в галузі маркетингу туристичної діяльності. У дослідженні використані методи, що забезпечують його логічну сутність – діалектичний метод наукового пізнання, метод системно-структурного аналізу, метод моделювання складних систем.

Ключові слова: туристична індустрія, ринок туристичних послуг, механізми маркетингу,нестабільне середовище, культурна індустрія, нетрадиційний туристичний продукт, промисловий туризм

Introduction. An important part of the strategy of modernization of the Ukrainian economy at the present stage is the transition from the industrial and raw material model of development to a post-industrial or creative model, based on the use of human potential and knowledge, which is a certain basis for the development and implementation of ideas for the cultural and economic development of the modern metropolis. It is the modern industrial city that presents the main indicators of the state of unstable environment and acts as a complex socio-economic system.

The economic space of the modern city is an infrastructure whose main features are the uneven and non-linear process of creation and consumption of the tourist product; the multidimensionality of the tourist services market. The main signs of instability of the economic space of a modern industrial city are the formation of its structure in a directive economy with no internal incentives for self-development; performance of production tasks at any cost; the predominance of the influence of social factors; reorientation to the «consumption model» as opposed to the «development model», etc. In the given context, the search for effective marketing instruments for the development of the tourism industry becomes relevant.

Marketing activities are aimed at a deeper study of the motivation and psychology of consumers and other market participants in order to identify opportunities to influence them, involving the creation of new types of tourism product, technology, improvement of forms of product promotion, distribution channels and methods of entry into new markets. An analysis of the works of specialists in the field has shown that in order to obtain the most positive result in the market of tourist services, marketing activity should be carried out systematically and constantly. At the same time, it is important to choose a development strategy according to which marketing of services is considered as a special type of activity that shapes the social environment and conditions of life of society.

Materials and methods of research. People do not buy goods or services in the tourist market, but their functional capacity meets a specific human need. That is why one of the tasks of the marketing approach as the basis of the creative industry is to provide and disseminate information not about the properties of the tourist product, but about the real benefit and advantages for the client. It is important to study and shape the needs of customers and meet these needs with more effective methods than competitors, while improving the well-being of all members of society (Golubkov, 1999).

Today it is possible to state insufficient marketing awareness and lack of knowledge of both the managers of tourism enterprises and staff, as well as insufficient practical experience in this field. In general, 95.7% of tourist enterprises in Ukraine do not have a marketing department in their organizational structure. However, the way it works is not proof of the priority of the marketing concept. Research has

confirmed that authoritarian methods and the reluctance to change outdated management now prevail in the management of tourism enterprises in Ukraine. In other words, most directors of tourism enterprises (100% of the largest and largest, 96% of the medium and 95% of the small) are not ready to open access to all information at the enterprise and involve employees in making decisions and shaping the enterprise marketing policy (State Statistics Committee of Ukraine: Tourist flows in 2016).

In an unstable environment, its factors are beyond the control of the travel company. However, they do have a significant impact on customer behaviour. Therefore, they should be constantly taken into account not only when making marketing decisions but also in daily professional activities. We are talking about the peculiarities of the functioning of the modern metropolis: poor adaptation to global challenges; specifics of the urban environment of social interaction; lack of motivation of workers to raise their level of education; excessive technological load, etc.

In our opinion, the factors of instability of the environment characterized by a high level of interdependence should be studied and taken into account in professional activity in the tourism industry on a continuous basis (Fig. 1).

One of the directions of solving problems of development of the tourism industry as a component of socio-economic environment should be the formation of the market of tourist services, taking into account the possibilities of the region and its cultural characteristics. In particular, the development of regional cultural industries will be facilitated by cooperation with EU countries. In particular, this concerns «the Culture Bridges program», which was presented by Simon Williams, Director of the British Council in Ukraine, on October 20, 2017, as part of «the Creative Ukraine» International Forum (Regional development strategies, 2019).

«The Culture Bridges» is a program for the development of the Ukrainian cultural sector aimed at establishing effective links between artists, cultural operators and institutions in Ukraine and the EU. The main objectives of the program are to promote cultural cooperation and intercultural dialogue between Ukraine and the EU through projects that enhance international mobility and cultural cooperation; promoting the capacity of the Ukrainian cultural and creative sector and the development of local cultural and creative industries; expanding Ukraine's participation in the EU's «Creative Europe» program projects; promoting mutual understanding and cultural diversity in Ukraine through internal cultural mobility and project initiatives.

Participation in the aforementioned programs will promote awareness of the importance of culture for economic development and social cohesion; developing knowledge and capacity of actors working in the cultural and creative sectors; encouraging wider public participation in cultural events, etc.

One of the directions of implementation of creative industries in an unstable environment should be the revival of old urban areas with already laid infrastructure, which saves on the development of new territories. Investors would rather invest in the development of a historic district or public open space in the historic center than anywhere else. The introduction of a real estate tax in Ukraine, the uniqueness and value of historic real estate will help to fill the local budgets (Bartoshuk, 2011).

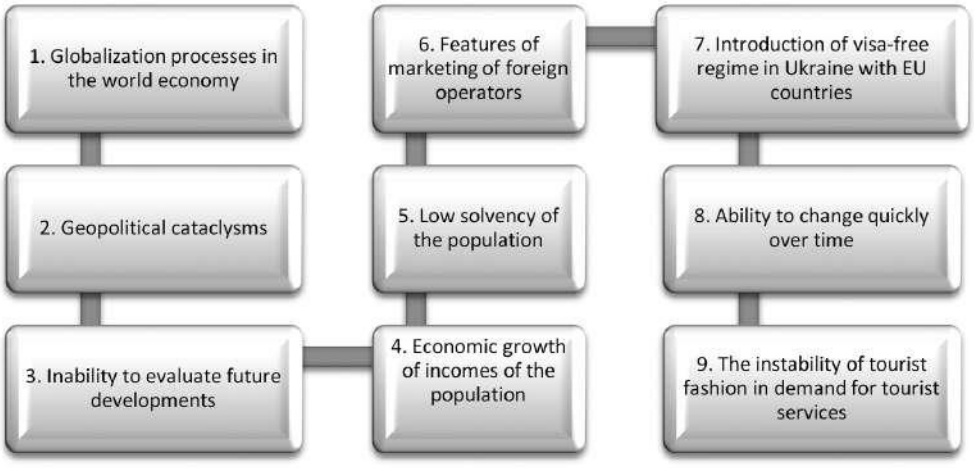

Fig. 1. Factors of unstable environment of the tourism industry. *Source: compiled by the authors*

Historic sites seem to have their own personality. And not for nothing, because buildings here are just as

important as people. The compactness of the building, the human scale of the buildings, the proportionality of the street space contributes to the intensity of communication. That is why historic districts are the most profitable places to start your own business, and why the most organized and active communities exist right here. A powerful and well-coordinated community is able to take care of its area, support individual members, organize joint and open events for everyone, and ultimately be responsible for the condition of the historic quarter or building without the involvement of outside money (Development of the tourism industry as a tool for economic development and investment attractiveness of Ukraine, 2019).

Important for the realization of the creative industries in the volatile environment of the modern city should be a private-public partnership based on the involvement of the community as a full participant in the successful preservation of cultural heritage as the basis of a creative economy. It can be characterized as: post-industrial economy, the main feature of which is the dominance of the service sector over manufacturing ; information economy based on the use of information - knowledge economy; an innovative economy, the main feature of which is the continuous production of ideas or innovations that are driven by dynamic changes in the market for consumption of services; a global network economy based on the interaction between the «carriers» of the idea on a global scale through the Internet. The priority direction of the creative economy should be the cultural policy of a particular region, the promotion of a city›s brand, the formation of its image and individuality (Gorina, 2015).

We have come to the conclusion that the creative industries, as a marketing technology at the present stage of development, are actively using cultural heritage and art as a resource to create new tourism products and services. Unfortunately, Ukraine has not developed a sustainable model for the preservation of historical and architectural heritage. Existing rules have the character of coercion, strict control and punishment for non-compliance, which does not contribute to the promotion and stimulation of non-state initiatives. Therefore, the question arises of creating the conditions and opportunities for interest and involvement of different participants in the preservation of cultural heritage, and the creation of an environment for encouraging mutually beneficial cooperation of all stakeholders. Often, public protests are the only possible way to stop the destruction of historic sites. However, such an approach can only guarantee the safety of a memory for a short time. An interesting example is the success of the cultural heritage preservation system in the Anglo-Saxon world, in particular the United States, based on productive interaction between the private and public sectors. In particular, the history of private initiative to preserve the national treasures of the United States is older than the National Park Service (an agency of the US Department of the Interior Affairs, an analogue of the central executive body that implements state policy in the field of cultural heritage in Ukraine). Currently, there are more than 160 partner organizations that assist the NPS in the conservation of national parks. A large number of national parks operate solely through private-public partnerships (World Tourism Organization. UNWTO, 2019).

The study and analysis of the United States' experience in the sustainable preservation of cultural heritage, modified to reflect the Ukrainian context, can serve as a model for an effective program to initiate and support the involvement of the private sector in preserving the cultural heritage of Ukraine and implementing creative approaches to the socio-economic development of the city (Eurostat, 2019), (Fig. 2).

Fig. 2. Chart of dynamics of tourist flows in Ukraine for 2010-2018

It should be noted that the modern creative industry of the socio-economic environment of the city involves the marketing of territories, which is a fundamentally new creative approach to social change and social processes in a democratic society. It implies a change in marketing strategy in order to build a new image of different types of tourism, because tourism is a powerful social force that is potentially able to achieve the greatest social goals. For this reason, territorial marketing is interpreted as the realization of a marketing creative paradigm in the socio-cultural sphere. According to our research the last ten years in Ukraine show an increase in outbound tourism in 2018 compared to the previous period and is 30%.

Given the statistic that 77% of Ukrainians have never left the country, the potential of the tourist services market in Ukraine, including industrial destinations, is far from being exhausted and has great potential.

An important aspect of the development of the tourism industry in an unstable environment is the consideration of factors affecting consumer psychology, among which the Internet is a priority. According to some experts, tourism companies over time are re-qualified as guides on computer networks, that is, the main task of tourism enterprises will be to help find the necessary information on the Internet. We thought it appropriate to analyze the use of networking as a marketing mechanism in the activities of travel companies Join UP, Anex Tour, TPG, TEZ Tour, Coral Travel, Pegas Touristik, TUI Ukraine, Accord Tour, GTO Travel Company. Of particular interest is the technique of British Internet technology specialist Anthony Jordanson, which determines the level of use of Internet resources (Daudzhest Uaneta, 2017). It proposes to assign a factor of –5 to +5 to each of the possible uses of the Internet involved in the enterprise, depending on the intensity and quality of use. According to this method, you can calculate the total coefficient of efficiency of Internet usage by any institution. To assess the level of use of Internet resources by tourism companies in Ukraine according to this method, we conducted a survey of experts in the tourism market.

A panel of 10 Internet experts was selected to conduct this research. In the previous phase, the objects of the study were identified with the experts. A representative group of nine Ukrainian travel companies (Join UP, Annex Tour, TPG, TEZ Tour, Coral Travel, Pegas Touristik, TUI Ukraine, Accord Tour, GTO Travel Company) was selected for the analysis. The average expert evaluation of the use of Internet resources by tourism business enterprises of the 9 top companies in the tourist services market in Ukraine is presented in Table 1. Certainly, TUI Ukraine is one of the largest tour operators in Ukraine, which opened the first interactive sales office; «Leader of the Year 2018» in tourism; it constantly expands the range of destinations and updates the line of hotels with special concepts of rest; TEZ Tour - an innovative company in the domestic tourism market; has its own departments, a wide selection of routes with an individual approach and orders via the Internet; Accord tour - with a wide range of discounts and special offers, etc.

As a result of the expert evaluation of the nine largest travel agencies of Ukraine, the total coefficients of efficient use of Internet resources were determined. As we can see, the following companies are included in the top three leaders -TUI Ukraine, TEZ Tour.

As we can see from Table 1, some of the companies are introducing new services to the tourist services market, such as: Travel Sim (virtual roaming service), virtual 3D tour of TUI Ukraine offices (total factor 51), virtual reality in offices, offering tours online, credit at 0%.

Some companies found innovations interesting. In particular, TUI Ukraine has launched the Regular flight program - online booking of regular flights; Coral Travel - has implemented Coral + Instant Booking, which is compatible with various mobile devices 24 hours a day. This company was recognized as the best in 2017 by participating in state tourism development programs aimed at social assistance for orphanages and veterans through cooperation with charitable foundations. TPG publishes the Travel magazine, which thoroughly covers the latest travel news, thematic tours to different countries. TEZ Tour Company (total factor of 43.5) implemented a system of excursions under the TEZ BONUS program in Turkey and Egypt; has a website that covers the material in three languages (English, Ukrainian and Russian), exhibits related materials for tourists (memorials, phone numbers of tourist support services, etc.). The company also invites tourists to take part in the Voluntary Registration of Citizens of Ukraine project, which aims to prevent and assist citizens of Ukraine in the event of unforeseen events while traveling. The company offers a social orientation project "Tour-Exchange", which takes into account all requests of the average consumer of tourist services of different age and social categories for the organization of excursion services during the tours (it is about taking into account the opportunities to purchase the tour at an affordable price, at the most convenient time, with advance booking of tickets, etc.).

As we can see, there is a clear tendency to increase this indicator depending on the status (rating) of the tourism company; by constantly expanding the

Table 1. Estimation of the level of use of Internet resources by tour operators by the method of Jordanson.
Source: compiled by authors [Daudzhest,2017]

Name of the means of use of Internet resources	Travel companies of Ukraine	Join UP!	Anex Tour*	TPG	TEZ Tour	Coral Travel	Pegas Touristik	TUI Ukraine	GTO Travel Company
Travel company website		+2	+3	+4	+5	+4	+3	+4	+3
Emailing		+3	+3	+3	+4,5	+3	+3	+4,5	+3
Banner and contextual advertising		+1	+4,5	+5	+4	+3	+1	+5	+2
Participation in joint projects and advertising on famous travel portals		+2	+3	+4	+4	+4	+2	+5	+2
Exchange links with other businesses and resources		+4	+4	+4,6	+4	+4,9	+2	+4	+2,5
Integration into online booking systems, on-line booking module		+2	+3	+4	+5	+4,6	+2	+4,5	+4,5
Virtual Tours: 3D tours of the company's offices		0	0	0	0	0	0	+5	0
Contextual mentions		2	+3	+3	+3	+3	+2	+3	+1
Online counseling, online surveys		0	+4	+4	+4	+3	+1	+5	+2
Advertising in social media		+2	+3	+3	+2	+2	+3	+4	+3
Mobile site		+1	+1	+1	+2	+5	+1	+3	+2
The total coefficient		20	31,5	36,6	43,5	36,5	20	51	25

range of use of new Internet resources, companies, thus creating sustainable competitive advantages of enterprises and enhancing their own competitiveness. The promotion of its services through the Internet space gives tourist companies a number of advantages over their competitors. The conducted research suggests that there is a direct relationship between the use of IT in the activities of tourism enterprises to ensure the effective implementation of marketing functions, to determine the prerequisites for ensuring the quality of tourism services in the context of the use of information technology. Marketing mechanisms include the development of programs for the benefit of a particular region, which include advertising, promotion, and the reputation for catering to the interests of large groups of people, whose totality is society.

The main purpose of marketing is to harmonize the interests of the organization, consumers and society as a whole, and therefore priority should be given to the formation of mechanisms to regulate the processes of development of the regional market of tourist services.

An interesting example is the Tourism Development Program in Dnepropetrovsk region for 2014-2022, which aims are to form an exclusive and diverse tourism product, promote it in the domestic and international markets through advertising and information campaigns (Dnepropetrovsk region tourism development program for 2014–2022).

Among the priority tasks of tourism development in Dnipropetrovsk region are: inclusion of industrial sites of Dnipropetrovsk region in the European Industrial Heritage Route (EIHR); development of industrial tourism; creation of hostels on the basis of dormitories of vocational schools and universities; promotion of rural green tourism and more. The Program emphasizes the significant recreational potential of the region, namely: there are 114 nature reserves and sites, 51 nature monuments, 8 landscape art parks, 3 protected tracts. In Dnipropetrovsk region there are 84 hotels, 130 recreation centers, 240 tourist organizations, about 200 of which work in the field of international tourism.

Large industrial cities saturated with enterprises of industrial complex infrastructure whose production processes pollute the environment are an example of ignoring the laws of development and reproduction of the natural resource base. That explains the traditionally biased public attitude towards depressed territories. Only if effective marketing technologies are implemented can the cultural potential of the region be realized.

Solving the problem requires considerable work to restore the harmonization of relationships between the individual, in particular the harmonization of their

needs and the natural environment, the study and implementation of industrial attractions, the effective use of anthropogenic and man-made landscapes, technological artifacts. The use of local resources as tourist and recreational potential is promising as a way of overcoming the negative image of the region. It is the development of industrial tourism as a creative industry that can preserve regional identity, stimulate the local service sector and the employment of the population.

Figure 3 presents a structural and functional model of the characteristics and characteristics of the tourist image of the region, components of its image policy. We have identified the structural elements of the tourist image of the region to which we have referred: the status of the tourist region, its appearance, regional symbolism, emotional connections with the region, tourist image policy and marketing of the region. In our opinion, the main factors for changing the tourist image are the economic situation in the region, urban planning, political situation and technical innovations, etc. In this context, marketing creative technologies are an example of a well-formed tourist image of the region.

World experience shows that industrial tourism for the enterprise itself is more a struggle for image, and indirectly for the prestige of the region in which it is located. For the enterprises of the region, the process of forming the image of socially-oriented production by transforming them into objects of industrial tourism should become an integral part of the strategy of innovative development. Industrial tourism is better than any kind of advertising, because having seen the quality process of production with his own eyes, the tourist becomes more loyal to the producer of a certain group of goods and services. Effective advertising of an industrial enterprise that does not require financial expenses is an effective means of additional profit and all this combines industrial tourism. A large number of domestic and foreign tourists are willing to pay money to see the production process with their own eyes. Not only the production of goods, but also the production of services can be turned into a show for tourists without sacrificing the production process (Meshko & Karplyuk,2015).

Today, Kryvyi Rih is taking confident steps to develop industrial tourism, in particular mining tourism. For example, PJSC "Kryvyi Rih Iron and Steel Works" officially introduced visits to the mines of the enterprise. Excursions are held on Fridays, and everyone who wishes to go to the tour operators in advance can get acquainted with the underground objects in person.

Given the current trends of economic development, the powerful industrial potential of our city and the need to diversify the economy, industrial tourism is emerging as a new promising phenomenon that can turn Kryvyi Rih into a tourist center (Strategic plan for the development of the city of Kryvyi Rih for the period until 2025, 2016).

The presence of such a non-standard tourist product as industrial tourism allows you to create creative excursion programs with unique objects: underground, transport, museums of industrial history, socio-cultural attractions related to the industrial past of the region. For example, in the city there are the following industrial excursions ; «Northern Lights of Kryvyi Rih», «Mining Kryvyi Rih», «Descent into the Operating Mine», etc.; sightseeing excursions « Night Kryvyi Rih from the Height of the Petrivskiy Dump», «Kryvyi Rih - the City of Ore and Metal»; the event excursions «Festival of Industrial Culture Night», «Along the Historic Streets of the Old Town», «The Old Gdantsevsky Mine», «To the Old Red Layer Mine», and others. As practice shows, tourist activity in large industrial centers suffers from a great deal of formalization, and therefore is oriented towards the production of relevant services as a commodity of mass culture. As tourists increase their needs for quality services, it is necessary to take into account environmental components and introduce the instrumental values of industrial tourism as a socio-cultural practice.

Industrial tourism can greatly enhance the image of the modern industrial region and city. The positive image of the industrial region will be formed more successfully under the conditions of: availability of excursions and other tourist services; meeting cognitive needs; cultural and educational actions; getting acquainted with the extraordinary, amazing results of the impact of industrial production technology on the geospatial landscape composition. It is industrial tourism that is able to meet the demand for excursions for certain social groups of the population, to influence the rational-careful attitude and use of natural resources. In particular, the experience of Kryvorizhzhya of planting trees and plants on waste heaps by residents of the city with the involvement of student youth is interesting (Ya.V. Shramko & V.L. Kazakov, 2013).

The main task should be to develop a new model of perception of industrial objects, which requires the development and implementation of a system of effective positioning. Note that a systematic approach to the development of the market of tourist services should be based on the principles of integrity, multifunctionality, development, multiplicity of system el-

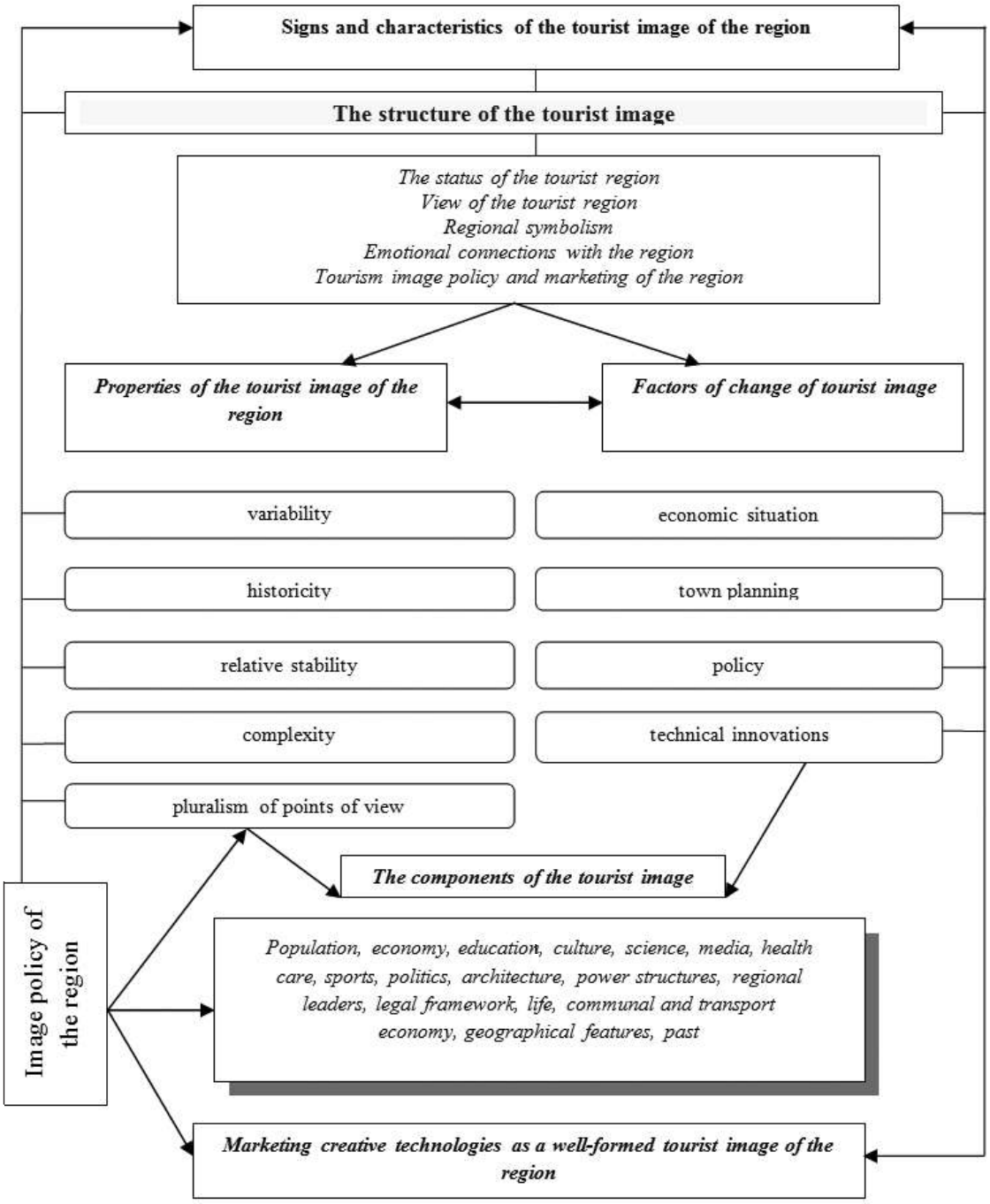

Fig. 3. Signs and characteristics of the tourist image of the region. *Source: Compiled by the authors*

ements, functional and structural structure, and so on. We have developed a structural and functional model of this system, which is a combination of sev- eral subsystems: systematization of types of industrial objects, positioning strategies (product differentiation, finding their niche, low cost strategy) and instruments for their implementation. An important component of the system is the instruments we have identified for the subjective positioning of an unconventional tourist product, which is an industrial heritage with its unique man-made entities. We considered the main elements of the system's implementation: preparation and dissemination of positive tourist information, knowledge of discriminatory barriers of target audience, etc. The elements of subjective positioning were defined: studying the peculiarities of the perception of industrial objects, motivation of their visits, the study of demand for industrial tourism, etc. These elements are aimed at the purposeful use of the life experience of consumers of tourist services which allow them to achieve psycho-physical relaxation, which will ultimately lead to the creation of a positive tourist image of the industrial region. It is the industrial enterprises or production processes that make it possible to form

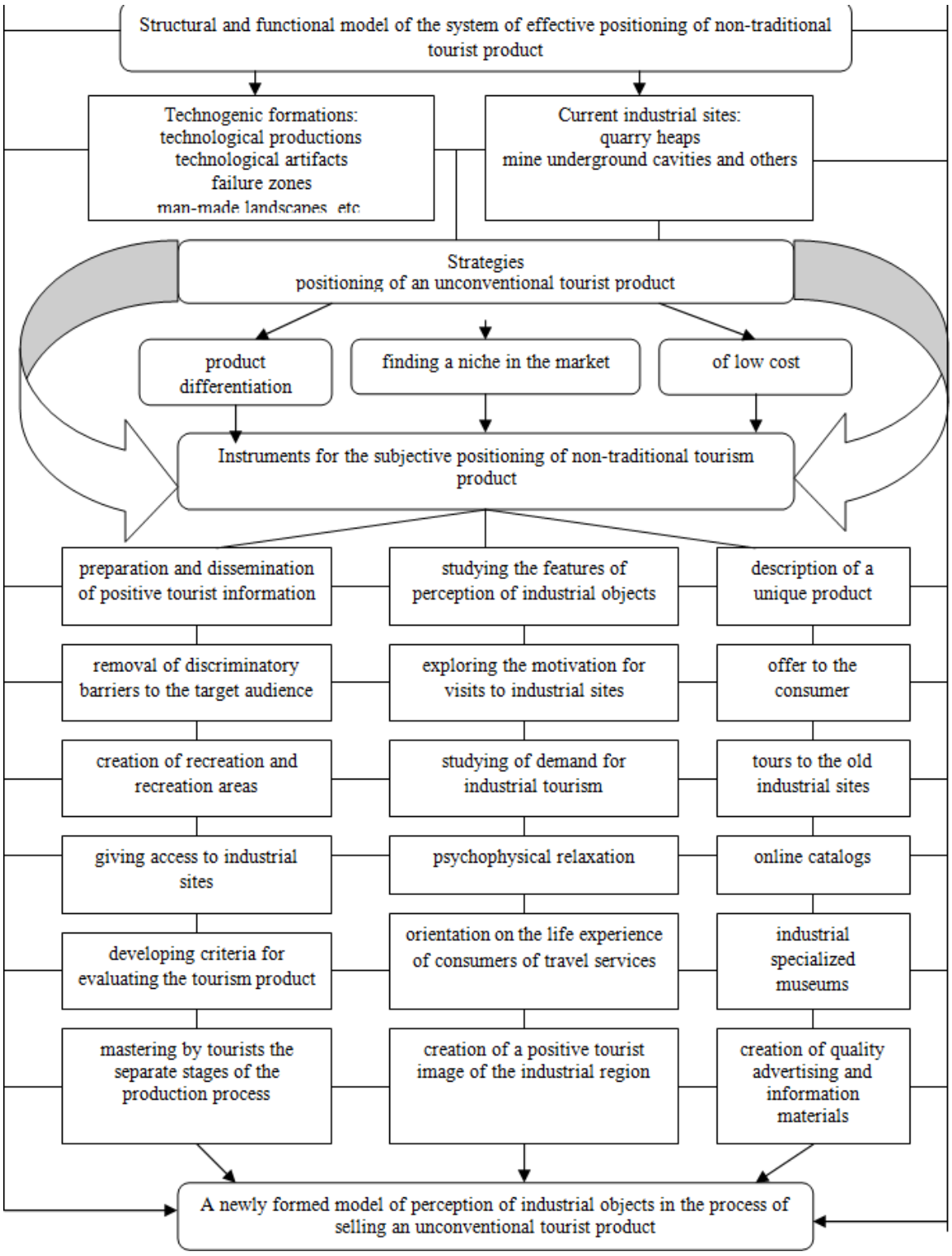

Fig. 4. Structural and functional model of the system of effective positioning of non-traditional tourist product.
Source: by the author

a unique offer for the consumers of tourist services, because they are able to give new impressions, knowledge and more, (Fig. 4).

The acquisition by tourists of insights into certain stages of the production process, the ability to access industrial sites will demonstrate the openness of enterprises to dialogue and communication with consumers of tourist services and will strengthen the positive opinion about the tourist object. It should be noted that the costs of organizing excursions to industrial sites are minimal, but they have a large informational impact (brand advertising, product lines, etc.), which affects the competitiveness of the territory. The researcher V L Kazakov believes that «within the an-

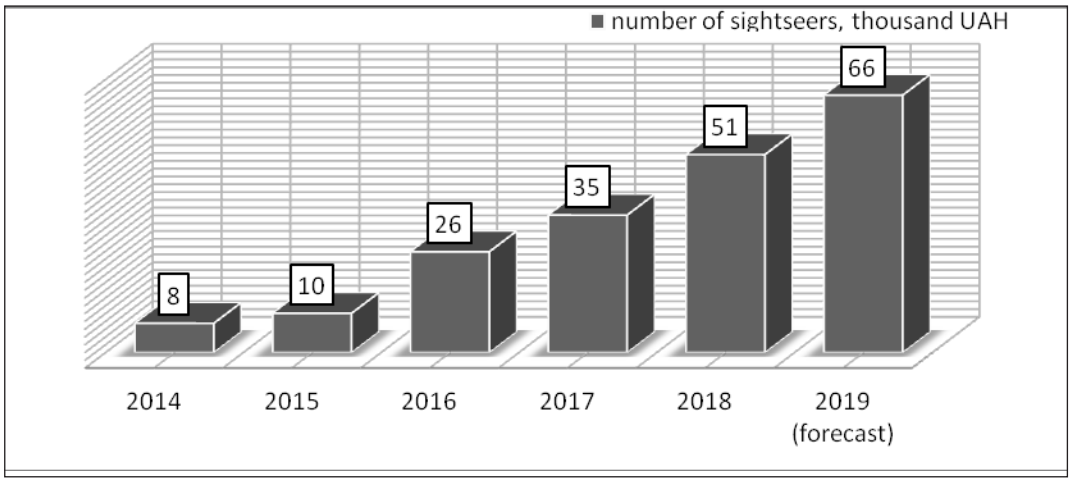

Fig. 5. Dynamics of the number of sightseers in Kryvyi Rih for 2014-2019 (14).

thropogenically altered territories, skills of harmonious relations between man and nature are acquired, and a resource-saving stereotype of behaviour at the level of personality is formed» (Kazakov, 2006).

Kryvyi Rih has an extensive multifaceted structure of industrial objects, various specialized industrial enterprises. The industrial heritage of Kryvyi Rih is: a system of unique mining and industrial landscapes of European importance, unique engineering and technogenic formations. The attraction of tourists to the region requires creative offers to the consumer of tour services with unique objects of industrial destinations, organization of tours of industrial objects, creation of unique industrial museums on the basis of quality advertising and information materials. At the same time, the achievement of the optimal tourist and recreational load for the preservation of tourist resources, and therefore the system of effective positioning of non-traditional tourist product, should become an important task. From our point of view, it is necessary to distinguish the concept of «system of effective positioning of non-traditional tourism product, which includes the typological structure of industrial facilities, positioning strategies and tools for subjective positioning, as well as the concept of» system of industrial facilities «(perceptions and motivation visitors) (Bogatyreva, Barabanova, 2019). Any system will be effective in terms of interaction of its components and subsystems, which bear the characteristics of the whole system.

The report on the implementation of the Program for the Development of Industrial Tourism in Kryvyi Rih in 2017 (approved by the City Council Decision on 31.01.2018) showed that the total amount of funds foreseen for the implementation of the Program activities in 2017 amounted to UAH 574 379,00, of which: 424 379,00 UAH. came from the city budget, while 150 000 UAH came from funds from other sources not prohibited by the current legislation of Ukraine. According to the results of the work, the funds spent from the city budget amounted to 354 582,00 UAH. In addition, other funds amounting to UAH 495,000 were raised for the implementation of the Program during the reporting period respectively in 2018 - UAH 588,144.

To achieve the efficiency and quality of the implementation of the Program, the department of industrial tourism is based on the municipal enterprise «Institute of Development of the City of Kryvyi Rih» of the Kryvyi Rih City Council; there is a city working group on tourism development in the city of Kryvyi Rih, which ensures coordination of urgent issues identified by the Program. We considered it expedient to follow the dynamics of the number of sightseers who used the services of local tour agencies in Kryvyi Rih during 2014-2019pp. (Strategic plan for the development of the city of Kryvyi Rih for the period until, 2025), (Fig.5).

One of the key factors for the successful development of industrial tourism is the creation of a diverse system of tourist excursion routes. The city has developed, tested and improved 71 tourist routes of varying complexity, 14 of which during 2017. An important element in the development of the tourism industry is the activity of economic entities that sell the tourism product (tour operators, travel agencies, etc.). According to the results of monitoring, 6 travel agencies of Kryvyi Rih organize and conduct city excursions (Pacyuk, 2008).

Industrial tourism is an important component forming the tourist image of the region, because conducting industrial excursions satisfies the need for people for rest and knowledge; very often this is associated with business visits. Specialists define the meaning of the term «industrial (manufacturing) tourism» from different points of view: as a designation of

travel to places related to industry (V. O. Sorochan); as a way of studying industrial architecture, exploring landscapes of industrial importance (V. S. Patsyuk). Industrial tourism, as part of the tourist services market, promotes mine tourism, food industry visits, quarries and tourism to sites of man-made disasters (such as the Chornobyl NPS) (Meshko & Karplyuk, 2015).

We fully agree with the view that conducting industrial trips to businesses not only attracts new staff but also creates a positive image of the region as a whole (Regional development strategies, 2019). The openness of the enterprises to visit allows Ukrainian and foreign tourists to get acquainted with their production processes, working conditions, and increase their overall level of development. Such excursions are a strong marketing move because the company has the opportunity to demonstrate its power, advantages over its competitors, attract new buyers or investors, and thereby increase its revenues (Matuzko, 2009).

Conclusion. Having studied the marketing mechanisms of tourism industry development in an unstable environment, we came to some conclusions. The modern economic space demonstrates the many dimensions of the tourist services market, built on the mobility and variability of factors of an unstable environment (this concerns unpreparedness for global competition and turbulence).

The indices of unstable environment determined by the authors prove that the modern industrial city presents the influence of factors of the given environment on the tourism industry. This concerns the need to implement innovative marketing mechanisms that will affect the development of the region. These mechanisms include: cooperation between producers and consumers of tourism services (primarily information) based on the establishment of a feedback mechanism and flexible response to changes in requests of consumers of tourist services; implementation of measures to preserve the cultural heritage of the region based on the implementation of regional cultural industries; variability of communication tools (public consultations, open method of coordination, structural dialogue, etc.) and constructive interaction of public organizations with the government; realization of instrumental values of industrial tourism as a socio-cultural practice by means of marketing technologies through formation of a new model of perception of industrial objects; improvement of forms of promotion of products, distribution channels and methods of entering new markets in conditions of unstable environment. This will contribute to the socio-economic development of the modern city area and the development of the tourism industry in the region.

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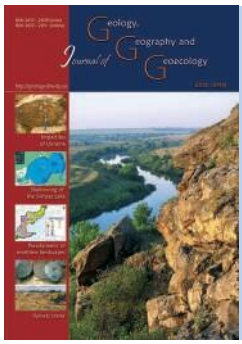

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World mineral deposits in the table of periodic chemical elements

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Abstract. The distribution of mineral deposits and the distribution of chemical elements on the globe are characterized by heterogeneity. A wide range of publications of domestic and foreign specialists - geologists, geographers, geochemists, economists - were dedicated to mineral resources of the world, mineral deposits. During processing the material the comparative-geographical, cartographic (analysis of minerals maps, mineral resources in the context of continents and regions of the world, cartographic interpretation of Mendeleev periodical table), monographic (analysis of fundamental works of leading domestic and foreign geologists and resource scientists, geologists and geologists, and geologists and geologists) directories, multi-volume editions devoted to geology and mineral resources of individual countries and regions of the world) methods, systematic approach, and GIS technologies - all these were used for received data processing and systematization. Explored mineral deposits (current and potential) form on the planet both individual local deposits and geochemical zones – areas where economically valuable chemical elements and their compounds are concentrated, which are diverse in genesis, stocks, and possibilities of exploitation. The largest of the latter is the Appalachians in the US - the Western Hemisphere, the Highveld in South Africa, Khibiny and the Ural Mountains in Russia - the Eastern Hemisphere. The leading countries in which most geochemical resources are extracted from the subsoil are the United States (65% of the total elements of Mendeleev periodical table), Russia (48%), China (38%), Canada (38%), South Africa (30%), Australia, (27%), Kazakhstan (19%), India (14%), Mexico (13%). The ideas about the level of provision of mineral resources and minerals in individual countries and territories of the world were systematized. The Mendeleev periodical table and its mineral and raw content were presented as an objective factor in the international geographical distribution of labor. The illuminated issues are confirmed high density of interdisciplinary links (geology, geography, chemistry, geochemistry, ecology, economics, regional studies, zoning).

Keywords: mineral and raw resources, minerals, countries and territories, system of chemical elements, Mendeleyev periodical table, deposits, mapping and structural-logical models

Світові родовища корисних копалин в періодичній системі хімічних елементів

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Анотація. Поширення родовищ корисних копалин та розподіл хімічних елементів на земній кулі характеризується неоднорідністю. Мінерально-сировинним ресурсам світу, родовищам корисних копалин присвячений значний масив публікацій вітчизняних та зарубіжних фахівців – геологів, географів, геохіміків, економістів. При опануванні матеріалу використовувались порівняльно-географічний, картографічний (аналіз карт корисних копалин, мінерально-сировинних ресурсів в розрізі материків і регіонів світу, картографічна інтерпретація таблиці Д.І. Менделєєва), монографічний (аналіз фундаментальних праць провідних вітчизняних та зарубіжних геологів та ресурсознавців, геологічних та мінерально-сировинних довідників, багатотомних видань, присвячених геології та мінерально-сировинним ресурсам окремих країн та регіонів світу) методи, системний підхід, при обробці та систематизації даних застосовувались ГІС-технології. Розвідані родовища мінеральної сировини (актуальні й потенційні) утворюють на планеті як окремі локальні поклади, так і геохімічні пояси – ділянки, де сконцентровані економічно цінні хімічні елементи та їх сполуки, різноманітні за генезисом, запасами, можливостями експлуатації. Найбільшими з останніх є: Аппалачі в США – західна півкуля, Високий Велд в ПАР, Хібіни та Урал в Росії – східна півкуля. Країнами-лідерами, на території яких з надр видобувається найбільше геохімічної сировини, є США (65% загальної кількості елементів таблиці Менделєєва), Росія (48%), Китай (38%), Канада (38%), ПАР (30%), Австралія (27%), Казахстан (19%), Індія (14%), Мексика (13%). Систематизовані уявлення про рівні забезпечення мінерально-сировинними ресурсами та корисними копалинами окремих країн та територій світу. Таблицю Д. І. Менделєєва та її мінерально-сировинне наповнення представлено у вигляді об'єктивного чинника міжнародного географічного розподілу праці. Висвітлена про-

блематика підтвердила високу щільність міжпредметних зв'язків (геологія, географія, хімія, геохімія, екологія, економіка, регіоналістика, районування).

Ключові слова: мінерально-сировинні ресурси, корисні копалини, країни та території, система хімічних елементів, таблиця Д.І. Менделєєва, родовища, картографічні та структурно-логічні моделі

Introduction. The idea and materials of this article were discussed by one of its authors with the acad. V.V. Skopenko back in 1994, whose constructive remarks were gratefully taken into account in this publication. The territorial distribution of mineral deposits and the distribution of chemical elements on the globe are characterized by heterogeneity. This heterogeneity is reflected by the following range of mineral resources in the territory: ***very low → low → medium → high → very high***. The extreme links of this range are, for example, Denmark (very low range of mineral resources) and South Africa (very high range of mineral resources). With regard to the three central links, mineral resources, for example, of Japan (low), Spain (medium), Kazakhstan (high), can correspond to them. For example, Ukraine occupies the third (middle) link in this range (Gursky, Yeysipchuk, Kalinin, 2006.). This publication serves as the objective basis for such assessments and aims to demonstrate a certain raw, energetic independence of the countries of the world as to supplying of the most important minerals (it demonstrates the "mineral-raw" filling of D. Mendeleev's periodic table).

Literature review. A huge array of publications by domestic and foreign specialists such as geologists, geographers, geochemists, economists - monographs (Beydik, Padoon, 1996; Gursky, Yeysipchuk, Kalinin, 2006; Lunev, Pavlun, 2013; Voyloshnikov, Voyloshnikova, 1991; Yatsenko, Kiptenko, 2009), encyclopedias and encyclopedic reference books (Biletsky, Boyko, Dovgy, 2004, 2007, 2013), laws, by-laws acts, certificates of copyright registration (State Service of Geology and Subsoil of Ukraine, 2016, February 29; Beydik, 2016, November 27), articles in scientific journals (Beydik, 2018, 2019) – were devoted to mineral-raw resources of the world and mineral deposits. On the other hand, D. Mendeleev's unique creation, his invention - periodic system of chemical elements is used for more than a century in numerous branches of the world economy. Filling the table's cells with qualitative characteristics, with examples of specific minerals globally, was one of the main tasks of this publication. The proposed material is positioned as an attempt of resource and geological, political and economic-geographical strengthening of D. Mendeleev's periodic table (Fig. 1), also demonstration of cross-curricular links in the study of geology, mineralogy, tectonics and geography. The map used a long, and the text - a short form of the table, although three forms of the Periodic Table of Chemical Elements are known: short (short-term), long (long-term) and ultra-long.

The purpose of the article is to provide a mapping and regional study interpretation of D. Mendeleev's periodic system of chemical elements and adapt it to systematize ideas about the distribution of minerals on the planet Earth (with a particular emphasis on the territory of Ukraine), using current ideas about the political map of the world and global geopolitical landscape, demonstration of the raw independence (or dependence) of the countries in the world.

Methods and methodology. In this section of the paper, we used comparative-geographical (analysis of the maps of minerals and mineral resources in the context of continents and regions of the world), cartographic (analysis of the world-wide deposits of major minerals, their cartographic interpretation of D. Mendeleev's table) (Fig. 2), modelling (structural-logical models building), monograph (analysis of fundamental works of leading domestic and foreign geologists and resource scientists, a geological and mineral resources reference books and dictionaries, multi-volume editions devoted to geology and mineral resources of individual countries and regions of the world) methods, systematic approach and modern computer technologies (Arc GIS Online, Adobe Illustrator CC). Making cartographic models we used both GIS technology and classical methods of cartographic imagine (badges, cartograms and charts).

Results and discussion. It should be noted that today 2200 minerals have been found on the globe, however, 10 of them are the most widespread in nature, and 118 elements are presented in the Mendeleev's table. The information in the table's cells was completed by data on the location of minerals or the consolidation of certain chemical elements in the continents and parts of the world by country. Invaluable minerals for human life, development of industry, science, technology, agriculture, have unevenly spread on the globe. Explored mineral deposits (actual and potential) form on the planet both individual local deposits and geochemical zones – areas where concentrated economically valuable chemical elements and their compounds (minerals and rocks), diverse in genesis (origin), reserves, exploitation opportunities. The largest of the latter is the Appalachians in the US – the Western Hemisphere, the Highveld in South Africa, Khibiny and the Ural Mountains in Russia – the

Periods	Groups of elements									
					V					
I	^{1}**H**							^{2}**He**		
II	^{3}**Li** Chile, USA, China, Bolivia, Australia, Argentina, Canada	^{4}**Be** Brazil, USA, Argentina, India, China, Russia	^{5}**B** Turkey, USA, Argentina, Chili, Peru	^{6}**C** Chile, India, USA, Russia, Australia, South Africa, Angola, Germany, Sri Lanka	^{7}**N**	^{8}**O**	^{9}**F** China, Mexico, South Africa, Russia, Mongolia, France, Morocco	^{10}**Ne**		
III	^{11}**Na** USA, Chili, India	^{12}**Mg** Kazakhstan, Austria, Greece, Czech Republic, North Korea, China, Canada, Russia, USA	^{13}**Al** Australia, Brazil, Guinea, Russia, Transcaucasia, Kazakhstan, Slovenia, Suriname, Hungary, France, Jamaica	^{14}**Si** China, Brazil, USA, Norway, France, Russia	^{15}**P** Morocco, Kazakhstan, South Africa, USA, Jordan, China, Russia, Egypt, Nauru	^{16}**S** Ukraine, Russia, USA, Italy, Japan, Poland	^{17}**Cl** Germany, Spain, Russia, India, Poland, Ukraine	^{18}**Ar**		
IV	^{19}**K** Canada, Russia, Germany, Belarusian, USA	^{20}**Ca** USA, Germany, Austria, Italy	^{21}**Sc** Russia, China, Kazakhstan, Ukraine, Australia, Canada, Brazil	^{22}**Ti** Australia, South Africa, Norway, Canada, India, Brazil, China, Ukraine	^{23}**V** Russia, South Africa, Venezuela, USA, Kazakhstan, China	^{24}**Cr** South Africa, Kazakhstan, Zimbabwe, USA, India, Greenland, Finland, Albania	^{25}**Mn** South Africa, Ukraine, Kazakhstan, Georgia, Brazil, Gabon, Australia, Bulgaria	^{26}**Fe** China, Australia, Brazil, India, South Africa, Russia, Ukraine, USA	^{27}**Co** DR of the Congo, Cuba, New Caledonia, Zambia, Indonesia	^{28}**Ni** Canada, Russia, Australia, Cuba, New Caledonia
	^{29}**Cu** Chili, USA, Peru, China, Kazakhstan, Indonesia, Congo, Zambia, South Africa, Australia	^{30}**Zn** Russia, Australia, Kazakhstan, Canada, USA, China, India, South Africa	^{31}**Ga** USA, Great Britain, Italy	^{32}**Ge** USA, Canada, Bolivia	^{33}**As** USA, Sweden, Mexico, Japan, Bolivia	^{34}**Se** Kyrgyzstan, Russia, Congo, Bolivia, Germany, Argentina, Romania	^{35}**Br** Turkmenistan, Israel, Russia, Ukraine, Bulgaria	^{36}**Kr**		
V	^{37}**Rb** Canada, USA, Sweden	^{38}**Sr** Mexico, Canada, Spain, Great Britain, Italy, Argentina, USA	^{39}**Y** Sweden, USA, Italy	^{40}**Zr** Norway, Brazil, USA, Sri Lanka, Madagascar	^{41}**Nb** Brazil, Canada, India, Malaysia, Russia	^{42}**Mo** Russia, USA, Chili, China, Peru, Armenia, Kazakhstan	^{43}**Tc**	^{44}**Ru** South Africa, USA, Russia, China, Zimbabwe, Canada	^{45}**Rh** South Africa, USA, Russia, Zimbabwe, China, Canada	^{46}**Pd** South Africa, USA, Russia, Zimbabwe, China, Canada

V	^{47}**Ag** Poland, USA, Canada, Peru, Mexico, Chili, Australia, Kazakhstan, Tajikistan, Bolivia, Russia	^{48}**Cd** USA, Canada, Australia	^{49}**In** Canada, USA, Bolivia	^{50}**Sn** Brazil, China, Indonesia, Malaysia, Thailand, Russia, Bolivia, DR of the Congo	^{51}**Sb** China, Russia, Tajikistan, Bolivia, Thailand	^{52}**Te** USA, Japan, Mexico	^{53}**I** Chili, USA, Mexico	^{54}**Xe**		
VI	^{55}**Cs** Italy, Canada, USA	^{56}**Ba** Great Britain, USA, Italy, Russia, Romania	^{57}**La*** USA, South Africa, India	^{72}**Hf** Nigeria, Norway, USA, Canada	^{3}**Ta** Saudi Arabia, Greenland, North Korea, France, Mozambique, Australia	^{74}**W** China, Kazakhstan, Russia, USA, Canada	^{75}**Re** USA, Mexico, Chili, Canada	^{76}**Os** South Africa, USA, Russia, Zimbabwe, China, Canada	^{77}**Ir** South Africa, USA, Russia, Zimbabwe, China, Canada	^{78}**Pt** South Africa, USA, Russia, Zimbabwe, China, Canada
	^{79}**Au** China, Australia, USA, South Africa, Peru, Russia	^{80}**Hg** Spain, Italy, China, Kyrgyzstan, Canada, Australia, South Africa, China	^{81}**TI** USA, Spain, Norway	^{82}**Pb** Russia, India, Kazakhstan Canada, Australia, South Africa, China	^{83}**Bi** Australia, Mexico, Japan,	^{84}**Po** USA, Mexico, Canada, Russia	^{85}**At**	^{86}**Rn**		
VII	^{87}**Fr**	^{88}**Ra**	^{89}**Ac****	^{104}**Rf**	^{105}**Db**	^{106}**Sg**	^{107}**Bh**	^{108}**Hs**	^{09}**Mt**	^{110}**Ds**

Lanthanides													
^{58}**Ce**	^{59}**Pr**	^{60}**Nd**	^{61}**Pm**	^{62}**Sm**	^{63}**Eu**	^{64}**Gd**	^{65}**Tb**	^{66}**Dy**	^{67}**Ho**	^{68}**Er**	^{69}**Tm**	^{70}**Yb**	^{71}**Lu**
^{90}**Th**	^{91}**Pa**	^{92}**U** Australia, Canada, Kazakhstan, Russia, South Africa, Namibia, USA, Brazil	^{93}**Np**	^{94}**Pu**	^{95}**Am**	^{96}**Cm**	^{97}**Bk**	^{98}**Cr**	^{99}**Es**	^{100}**Fm**	^{101}**Md**	^{102}**No**	^{103}**Lr**

Fig 1. World mineral deposits in terms of countries and territories in the periodic system of chemical elements (D. Mendeleev's Periodic Table) (Beydik, 2018, with refinements)

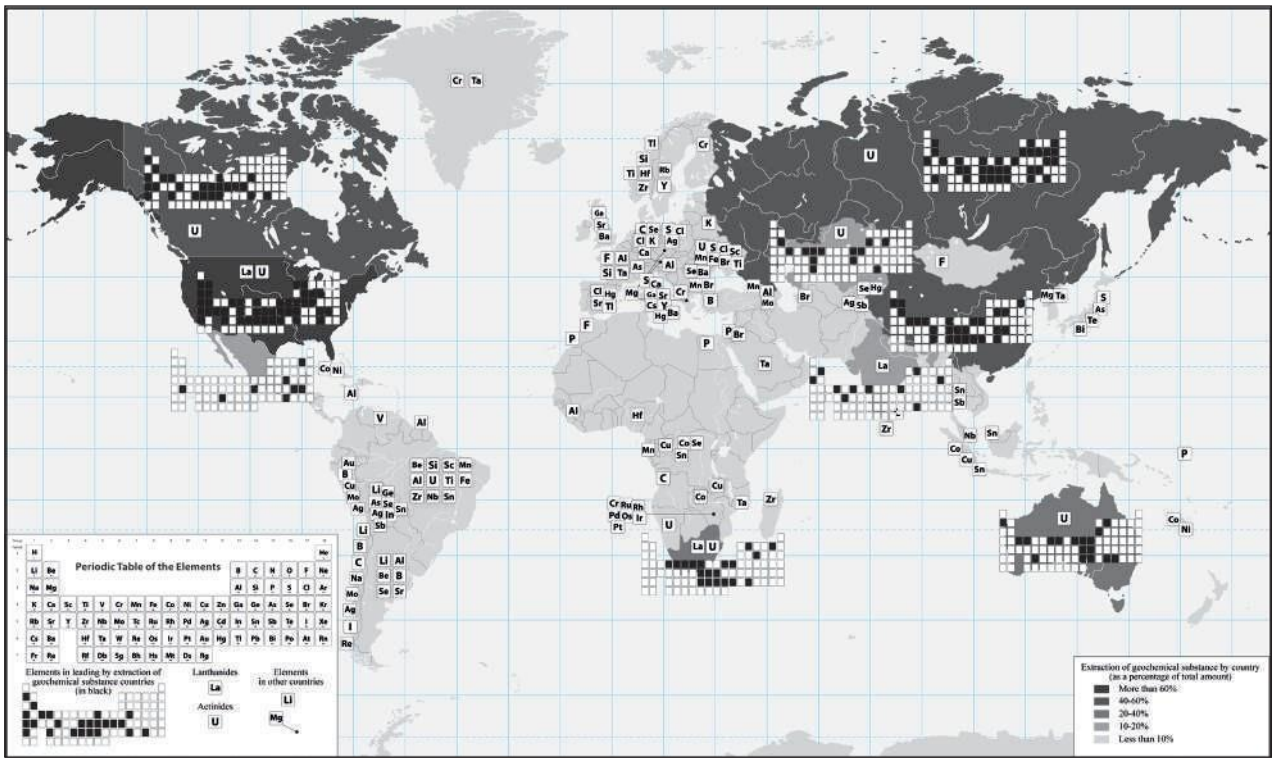

Fig. 2. The world leading countries for mineral resources in D. Mendeleev's periodic table (designed based on Beydik, 2018)

Eastern Hemisphere. D. Mendeleev's table, where the countries and territories of the location and production of the chemical elements are indicated that correspond to specific minerals and mineral resources (Fig. 1), and the provision of individual countries and regions gives a systematic conception of the global distribution of chemical elements that are a part (geochemical) of compounds (rocks, minerals, minerals).

This paper contains the data for the last 20-25 years about the extraction of the most important raw materials on the Earth (including the countries of the former USSR) was summed up, systematized and generalized. The place of a country in the table's cells may not coincide with the production of natural resources or the producing of clean products.

The number of countries and regions within a specific order number (from three, for example, No 11 – «sodium» to eleven in No 13 – «aluminum»), and their place in group (I-VI) are not constant, canonical quantities, and those that have to be taken dialectically, in development - with possible additions, remarks or objections. The table should help form a systematic approach to the study of natural resources, mineral deposits, remind of their connection with the political map of the world, the importance of understanding certain provisions of geology, chemistry, government, the degree of economic development, natural resources using, about cross-curricular connections.

The countries which lead in the most geochemical resources are extracted from the subsoil are the United States (65% of the total elements of D. Mendeleev's periodic table), Russia (48%), China (38%), Canada (38%), South Africa (30%), Australia, (27%), Kazakhstan (19%), India (14%), Mexico (13%) are confirmed by fig. 1 and 2. The name of at least one country (for example, Albania in cell No 24 – chromium) can be the basis for its inclusion in one or another part of the international geographical division of labor, information regarding its specialization in the world market of mining and chemical raw materials, etc.

Thus, acquaintance with the map (Fig. 2) gives grounds to identify four conditional areas of relative concentration of minerals: North American (USA, Canada, Mexico - more than 60% of the total number of table elements), North Asian (Russia – about 50%), Central Asian (China, Kazakhstan – about 40%) South Asian (India – about 15%), which indicates not only significant current deposits, but also on the high mineral potential of these territories (latent deposits). At the same time, a significant part of the globe still remains a mineral terra incognita, the bowels of which are waiting to be used. This factor is fundamental that will give humanity optimism about its future, isn't it?

It is natural that Ukraine is not in this top-9, because it cannot compete with such "mineral heavyweights". At the same time, in terms of minerals it has enough high chance to get into the leading countries and find its own cells in Mendeleev's table (Table 1).

Table 1. Mineral raw material independency of Ukraine, 2013-2018

Mineral	Production position in Europe	Production position in the world
Uranium (U)	*1 (2015)*	*12 (2015)*
Iron (Fe)	*1 (2015)*	*6 (2015)*
Manganese (Mn)	*1 (2015)*	*8 (2015)*
Natural gas	*3 (2013)*	*31 (2013)*
Titanium (Ti)	*3 (2015)*	*12 (2015)*
Lithium (Li)	*1 (2018)*	*13 (2018)*

Today, coal mining (1.7% of the world's total production), commodity iron (4.5%) and manganese (9%) ores, uranium, titanium, zirconium, graphite (4%), kaolin (18%), bromine ochre, non-metallic metallurgical raw materials (quartzite, flux limestones and dolomites), chemical raw materials (native sulfur, rock and potassium salts) are produced in considerable volumes in Ukraine. Hydrocarbon raw materials, brown coal, peat, cement raw materials, heat-resistant and refractory clays, raw for the production of building materials, iodine, bromine, various mineral waters, precious and precious stones, piezo quartz are also produced in Ukraine (Beydik, 2018).

Chemical elements in the free state occur very rarely, more often they are part of various compounds, so we consider them as constituents of minerals (Table 2), for example: copper (Cu) is a component of copper(i) sulfide (Cu_2S), tetrahedrite ($Cu_{12}Sb_4S_{13}$), copper iron sulfide ($CuFeS_2$); lead (Pb) is a part of lead(II) sulfide (PbS), boulangerite ($5PbS * 2Sb_2S_3$), lead carbonate ($PbCO_3$); silicon (Si) is composed of quartz (SiO_2), opal ($SiO_2 * nH2O$), silicon dioxide (SiO_2), staurolite ($Fe [OH]_2 * 2Al_2SiO_5$), and twenty others. And so is every element. Various combustible hydrocarbons (CH_3 and CH_4) in the mixture are included in the oil. Inert elements are a constituent of combustible gas.

Water resources, climate, land resources, flora and fauna should be considered as natural resource potential in addition to the considered minerals. Survey

Table 2. World mineral recourses (designed based on Beydik, 2019)

Elements of rock-forming minerals	Rock-forming minerals	The main deposits
Aluminum	bauxite, alunite, staurolite, pyrophyllite, augite, epidote, spesartine, almandine, pyralspit	Bauxites: Australia, Brazil, Guinea, Kazakhstan (Torgay), Russia (North & South Urals, Siberia, Kola Peninsula), Slovenia, Suriname, Hungary, France, Jamaica, Nifeline Sienites: Transcaucasia and Trans-Baikal, Alunzites: Transcaucasians
Barium	barytes	Accumulations of large crystals - Cumberland, Cornwall, Westmoreland and others. (England), Felshoban (Romania), in the form of nodules in marls - Paterno (Italy), massive deposits in the states of Arkansas, Georgia, California, Missouri, Oklahoma, Tennessee (USA), Russia (Kuzbass, Khakassia)
Beryllium	beryl, freakin, chrysoberyl, etc.	Brazil, USA, Argentina
Carbon	diamonds, graphite, calcite, magnesite, dolomite, siderite, smithsonite, aragonite, cerusin, malachite	China, India, USA, Russia, Australia, Germany, Angola, South Africa
Iron	pyrrhotite, chalcopyrite, pyrite, marcasite, arsenopyrite, hematite, magnetite, chromite, ilmenite, goethite, limonite, siderite, vivonite, staurolite, olivine, augite, egerin, muscovite, biotite, vermiculite, epidote, chlorite	China, Australia, Brazil, India, Russia, Ukraine, South Africa, USA, Canada
Gold	-	China, Australia, USA, South Africa, Peru, Russia.
Potassium	alunite, muscovite, biotite, lepidolite, sylvin, nepheline, feldspars	Canada, Russia, Germany, Belarus, USA, Ukraine

Calcium	calcite, dolomite, aragonite, anhydrite, epidote, diopside, augite, fluorite, chabazite, titanite	USA, Germany, Austria, Italy
Silicon	quartz, opal, chalcedony, staurolite, olivine, pyralspit, almandine, spesartine, epidote, diopside, augite, aegirine, talc, pyrophyllite, chlorite, muscovite, biotite, lepidolite, verminulite, topaz, titanite, zircon	China, Brazil, USA, Norway, France, Russia
Lithium	lepidolite	Chile, USA, China, Bolivia, Australia, Argentina, Canada
Magnesium	magnesite, dolomite, olivine, pyralspit, diopside, augite, talc, chlorite, biotite, bischofite, vermiculite	Kazakhstan, Austria, Greece, Czech Republic, North Korea, China, Canada, Russia (Urals, Baikal region, Krasnoyarsk region), USA
Manganese	pyrolusite, manganite	South Africa (Kalahari), Ukraine (Manganese), Kazakhstan (Jessazgan), Georgia (Chiatura), Brazil (Urukum), Gabon, Australia (Grte Island), Bulgaria (Obrochishte)
Arsenic	realgar, auripigment	The United States (Butte, Gold Hill), Sweden (Buliden), Mexico (Mateuala, Chihuahua), Japan (Kassioka, Sasatatani), Bolivia (Potosi)
Copper	malachite, azurite	Chile, USA, Peru (San Rafael), China, Kazakhstan, Indonesia, Congo, Zambia, South Africa, Australia
Molybdenum	in the composition of molybdenite	Russia (Sorske, Tirniauz), USA (Climax, Henderson), Chile, China, Peru, Armenia, Kazakhstan
Sodium	nitrate, mirabilite, aegirine, nepheline, halite, feldspars	Deposits: Chile, USA, India
Nickel	nickel, millerite, pentlandite	Canada, Russia, Australia, Cuba, New Caledonia
Niobium	pyrochlor, columbite	Deposits: Brazil (Goias, Minas Gerais), Canada, India, Malaysia, Russia (Lovozero)
Tin	cassiteritis	Brazil, China, Indonesia (Bank and Belitung Islands), Malaysia, Thailand, Russia (Saha), DR Congo, Bolivia (Morocco)
Platinum	platinum group metals (palladium, iridium, rhodium, osmium, ruthenium)	South Africa (Bushveld), Russia, Zimbabwe, Canada, USA
Mercury	cinnabar	Spain (Almaden), Italy, China (Wanshan), Kyrgyzstan, Algeria (Mra-S'Ma), Ukraine (Nikitovske)
Lead	galena, bulanerite, cerusite	Russia (Gorevskoye), India, Kazakhstan (Zhairem), Canada (Brunswick, Sullivan), Australia (Broken Hill, MacArthur River), China, South Africa
Selenium	-	Kyrgyzstan (Akjilga), Russia (Upper-Seymchansk), Bolivia (Pakahaka), Germany (San Andreasberg), Argentina (Sierra de Umango), Congo (Shinkolobwe), Romania (Nagyag, Fatze-Baia)

of the table, the map and the relevant publications indicate that mineral-heavy heavyweights are also the world's largest environmental pollutants. Thus, according to the Blacksmith Institute (USA) in recent years, the dirtiest places in the world are a number of Chinese and Indian industrial cities (Linfen, Tianjin – in China, Sukinda – in India, where chrome ore is mined). The illustrative component of the article (the table of chemical elements and the map) is considered as a separate demonstration of the geopolitical power of individual states – planetary and regional mineral resources leaders, a factor of global interstate strategic relations. There is a regular pattern: the larger the country's territory, the more diverse and numerous its mineral resources (for example, all top 9 countries have an area from 1 million to 17 million km^2 and are the largest in the world). The "white spots" on the map are intended to induce the search for latent areas of mineral resources, and their antipodes – places of concentration of minerals – to motivate the scientific and practical «key factors» to intensify and higher efficiency of the use of natural resources. Antarctica

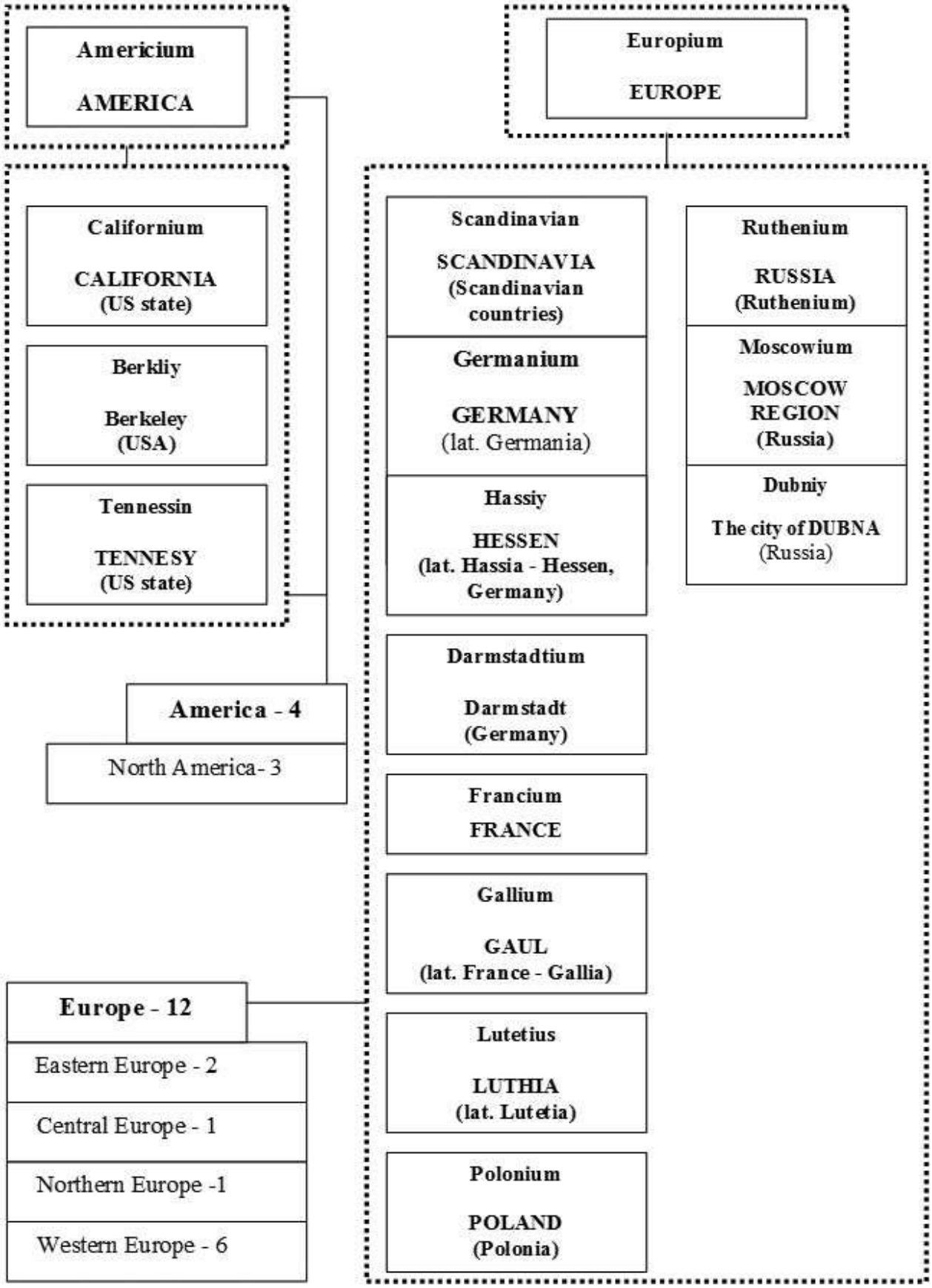

Fig. 3. Etymological-geographical and structural-logical model of the periodic system of chemical elements (based on Beydik, 2019)

has been set aside in Fig. 2, taking into consideration that it's international, specific status and mode of development. But Antarctica is considered to be a «mineral resource Klondike» with its potentially colossal deposits of coal, oil, rare earth and precious metals. And water. If the 20th century was called the century of oil, the 21st century is the century of water. Only 90% of the world's freshwater reserves are concentrated in Antarctica.

It should be reminded, that D. Mendeleev's table presents 118 elements. Their names are related to their discovery history: one group honors the memory of distinguished scientists, the second one, as the discoverers wished, the names of the gods, and the third – geographical objects associated with the discovery history, the homeland of the discovery scientists, the cities (4 names) and territories (5 names) where these discoveries took place. Nowadays, there are 18 such elements: polonium – Polonia (Poland), californium – California (USA), germanium – Germany (lat. name of Germany – Germania), ruthenium - Russia, moscowium – Moscow (Russia), scandinavian - Scandinavia (Scandinavian countries), berkliy - Berkeley (USA), francium – France, dubniy – the city of Dubna (Russia), uranium – Uranus (planet of the solar system), neptunium – Neptune (planet of the solar system), americium – America, europium – Europe, gallium – Gaul (lat. name of France – Gaul), tennessin - Tennesy (USA state), lutetius – Lutetia (lat. Lutetia), hassiy – Hessen (lat. Hassia – Hessen, Germany), darmstadtium – Darmstadt (Germany). Figure 3 presents a visual-imaginary (structural-logical) model of the above, which elements of political and geographical zoning were determined by Yatsenko, Kiptenko, 2009. The figure 3 is also considered as an attempt to combine a geographical and etymological factors in interpreting a periodic table of chemical elements. A brief survey of the figure shows the dominance of the names of two parts of the world – Europe (12 names) and America (4 names), crowning both the territories, where the discovery of chemical elements took place and the national affiliations of pioneering scientists.

The visual and textual information contained in the article is open to interpretation and further steps to deepen and expand the understanding of qualitative and quantitative analytics of major world and regional mineral deposits.

Conclusions:

visual interpretation of the world's most important mineral deposits is submitted, which is reflected in D. Mendeleev's periodic table of chemical elements and cartographic model;

D. Mendeleev's table and its mineral raw material content are presented as an objective factor of the international geographical distribution of labor;

a cartographic interpretation of the periodic table of chemical elements in the context of hemispheres, continents, leading mineral resources was submitted for the first time;

ideas about the level of supply of mineral resources and minerals of individual countries and territories of the world were systematized;

top-9 countries of the most affluent by minerals were determined by the number of mentions of pairs "country – chemical element»;

an etymological-geographical structural-logical model of the periodic system of chemical elements has been proposed;

highlighted issues confirmed the high density of cross-curricular links (geology, geography, geochemistry, ecology, economics, regional studies);

the statements and the conclusions of the article can be implemented in the latest programs of reformed education in Ukraine.

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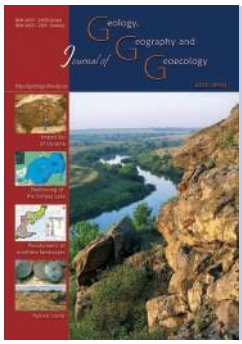

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Analysis of the market of international tourist services of Ukraine (for the period 2007-2017)

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Abstract. The state of development of the tourism industry in Ukraine for the period 2007-2017 is analyzed. It is established that it does not correspond to the existing potential of tourist resources, and the economic efficiency of the tourism industry is low. One of the main reasons for this situation is the lack of theoretical understanding of the socio-economic nature of tourism as a social phenomenon and its economic significance as a profitable industry. The tourism industry is one of the fastest growing sectors of the world economy. This increases the competitiveness of countries and regions, creating new jobs and improving living standards. It is proved that self-regulation of the tourist market is a necessary condition for its functioning. The dynamics of export-import of tourist services of Ukraine is analyzed. There is a tendency to a slight increase in the cost of services in the last years of the study period. In the interaction "government regulation - market" the primary link is the market, and government regulation is a tool that provides the general conditions of its existence, equalizes the conditions of the start of its subjects and eliminates, if possible, the negative manifestations of the market element. The activities of the tourism industry in Ukraine are analyzed. There is a tendency to reduce the number of enterprises in the tourism industry in recent years of the study period. The rating of tour operators by the number of served tourists and by the reviews of tourists is analyzed. The place and role of the Ukrainian tourism business in the world market of tourist services has been identified. The situation on the world market of tourist services of Ukraine is considered and it is concluded that one of the favorable conditions for tourism development in Ukraine was the adoption of visa-free regime with EU countries, the tourist market gradually recovered after the crisis of 2014, and Ukrainians begin to conquer Europe. 2017 can be called the year of tourism development in Ukraine: the flow increased rapidly, and the number of permits for sale, according to the State Statistics Committee of Ukraine, increased by 36%. Citizens of Ukraine who went abroad formed the group that used the services of tourism entities the most. It was found that the largest number of tourism entities is concentrated in the city of Kyiv and in Dnipropetrovsk, Kharkiv and Odessa regions.

Keywords: tourism, tourist, foreign tourists, international tourism, world market, tourist service, integration, Ukraine

Аналіз ринку міжнародних туристичних послуг України (за період 2007-2017 років)

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Анотація. Проаналізовано стан розвитку туристичної галузі в Україні за період 2007-2017 років. Встановлено, що він не відповідає існуючому потенціалу туристичних ресурсів, а економічна ефективність туристичної галузі є низькою. Однією з головних причин такої ситуації є відсутність теоретичного розуміння соціально-економічної природи туризму як соціального явища та його економічного значення як прибуткової галузі. Індустрія туризму - одна з найприбутковіших галузей світової економіки, яка найбільш швидко розвивається. Це підвищує конкурентоспроможність країн та регіонів, створюючи нові робочі місця та покращуючи рівень життя. Доведено, що саморегулювання туристичного ринку є необхідною умовою його функціонування. Проаналізовано динаміку експорту-імпорту туристичних послуг України. Встановлено тенденцію до незначного зростання вартості послуг в останні роки досліджуваного періоду. У взаємодії «державне регулювання – ринок» первинною ланкою є ринок, а державне регулювання виступає інструментом, що забезпечує загальні умови його існування, вирівнює умови старту його суб'єктів та усуває, за можливістю, негативні прояви елемента ринку. Проаналізована діяльність суб'єктів туристичної галузі в Україні. Встановлена тенденція до зменшення кількості підприємств туристичної індустрії в останні роки досліджуваного періоду. Проаналізовано рейтинг туроператорів за кількістю обслугованих туристів та за

відгуками туристів. Ідентифіковано місце та роль українського туристичного бізнесу на світовому ринку туристичних послуг. Розглянуто ситуацію на світовому ринку туристичних послуг України та підсумовано, що однією зі сприятливих умов для розвитку туризму в Україні було прийняття безвізового режиму з країнами ЄС, туристичний ринок поступово відновлювався після кризи 2014 року, і українці починають підкорювати Європу. 2017 рік можна сміливо назвати роком розвитку туризму в Україні: потік швидко збільшувався, а кількість дозволів на продаж, за даними Держкомстату, зросла на 36%. Громадяни України, які виїхали за кордон, складали групу, яка найбільше користувалася послугами суб'єктів туристичної діяльності. Було встановлено, що найбільша кількість суб'єктів туристичної діяльності зосереджена у місті Київ та у Дніпропетровській, Харківській та Одеській областях.

Ключові слова: туризм, турист, іноземні туристи, міжнародний туризм, світовий ринок, туристична послуга, інтеграція, Україна

Introduction. The modern tourism industry occupies a leading position in the world economic system. It accounts for about 10% of world gross output, about 30% of world trade in services, 7% of total world investment, 11% of world consumer spending. The World Tourism Organization provides statistics showing that revenues from international tourism have grown by an average of 9% per year over the past 16 years. For more than 40 countries, the tourism industry is the main source of revenue for the state budget, and for 70 countries it is one of its three main articles (Malska, 2008). Travel and leisure in today's world are becoming an integral part of the lives of people on all continents. The result is that in the cost structure of the average family, the cost of travel services is the fourth item after the cost of food, clothing and car maintenance.

Ukraine objectively has all the prerequisites for the intensive development of domestic and foreign tourism, namely – the peculiarities of geographical location and relief, favorable climate, rich natural, historical, cultural and tourist-recreational potential. This sector of the economy can bring the country to the state treasury up to 4 billion US dollars a month. However, in Ukraine its development is insufficient. This is primarily due to the difficult socio-economic situation in the country, the lack of effective regulation of incentives for the tourism industry, the lack of an effective strategy for the development of this industry at both national and regional levels (Parfinenko, 2015).

The variety of research on tourism confirms its complexity, relevance and ambiguity of this topic. However, it should be noted that a number of aspects of state regulation of tourism development in Ukraine do not yet have adequate and comprehensive coverage in the scientific literature. These include, in particular, the role, functions and powers of the state in this area, mechanisms of socialization of tourism and the role of territorial communities in the industry and so on. Today, the issues of scientific substantiation of the place and role of the tourism sector in the system of socio-economic priorities are extremely relevant. In other words, it is necessary to develop tactical and strategic directions for attracting foreign tourists to Ukraine in terms of integration into the world market of tourist services. The above determines the choice of topic and relevance of the study.

Research methods. The study uses literary, analytical, comparative, mathematical and statistical methods and the method of scientific systematization.

The purpose of the work is to analyze tourist services in Ukraine and identify ways to attract foreign tourists to the country in terms of integration into the world market of tourist services.

Results and their analysis. The tourism industry, given its significant impact on the economic and social development of the country, the branching of economic ties, needs regulation, support and careful control by the state. The issue of creating an effective structure for the management of the tourism industry at all levels, decentralization and deconcentration of power with a clear definition of the powers of each level is becoming especially important at the present stage of development of Ukraine. The transformation of Ukraine into a tourist state of world importance requires coordination of activities of various sectors of the economy, which depend on the quality of tourist services, including transport, trade, souvenir production, publishing and advertising, etc.

According to the Ministry of Economic Development, in 2016 Ukraine was among the 30 most attractive countries for foreign tourists, taking 27th place. According to the World Bank, Ukraine in 2017 successfully rose to 25th position. In 2018, this position was maintained. We will analyze the number of foreign tourists to Ukraine by country.

According to the World Bank, as of 2017, 14.2 million foreign tourists visited Ukraine. This figure is higher than the number of foreign tourists in Singapore, Denmark, Iceland and the Czech Republic, Switzerland, Norway, Australia, Sweden, New Zealand and other countries known for their ancient history, unique attractions and beautiful nature. Of course, France, with its capital Paris and the Eiffel Tower, continues to be the most popular country in the world, with 86.8 million travelers. The second and third places in the ranking were taken by Spain and the United States, which received 81 million and 77 mil-

lion tourists, respectively (UNWTO World Tourism Barometer, 2019). The World Bank figures coincide with the data of the State Statistics Service of Ukraine as of 2017, which recorded that compared to 2016, the number of foreign tourists increased by almost one million – from 13.3 million people to 14.2 million people. The Ministry of Economic Development of Ukraine gives almost the same figures and notes that the rate of inbound tourism in 2018 remained at the level of 2017 – a little more than 14 million people.

Traditionally, the leading suppliers of tourists to Ukraine are border countries – Moldova (4.4 million tourists in 2018), Belarus (2.6 million), Russia (1.5 million), Poland (1 million), Hungary (915 thousand) and Romania (740 thousand). The head of the Center for Tourism Development of Ukraine noted that these data are based on the number of border crossings, when this happens, when the same person is registered at the border several times. This issue is particularly important in the case of Moldova, which had a population of 3.5 million as of 2017. That is, a large number of tourists from border countries is not necessarily an indicator of tourist attractiveness, but, as often happens, a marker of close family, business and trade ties with the need to visit a neighboring country (Kravtsova, 2016).

We can trace the wavy trajectory of the dynamics of the tourist flow of Ukraine in Fig. 1. Thus, it should be noted that since 2011 the dynamics has gained positive values, but in 2014 there was a decrease in the total number of tourists due to the inability to visit the temporarily occupied territory of the Autonomous Republic of Crimea, Sevastopol and parts of Donetsk and Luhansk regions (Pavlenko, 2013). The share of foreign tourists in the structure of the tourist flow of Ukraine until 2013 was over 50.0%, and in 2008 reached 62.2% (25.4 million people), but since 2014 their share did not exceed 36.2%-35.0%.

The study analyzed statistics on the types of tourist trips by number of people as of 2017. We have identified five main categories that are characteristic of the Ukrainian market of tourist services. Among citizens who left Ukraine in 2017, 63% went on vacation, 34% went on business trips, and only about 1.0% went on specialized, sports tourism and medical treatment. The smallest number of people in 2017 traveled for sports tourism (1079 people) (Fig. 2).

In 2017, the country was visited by 9,782 foreign tourists, or 58% of the incoming tourist flow; 14% and 13% of foreign tourists came for treatment and business trips, respectively (Fig. 3).

In the structure of foreign trade in tourist services, exports decreased almost 2 times, from 51.9% in 2008-2010 (Zaÿtseva, 2012) to 25-27% in 2014-2017. There is a clear advantage of imports and an increase in the negative balance of 17 billion US dollars from foreign tourists in 2012 to 525.1 billion US dollars in 2017 (Fig. 4).

During 2014-2016, negative trends in tourism development were observed, such as a decrease in incoming tourist flows due to territorial, political changes and a sharp rise in the exchange rate.

Representatives of the Asian continent rank first in exports and imports of international tourist services to Ukraine with a share of 32% and 52%, respectively. In terms of exports, the second place is occupied by

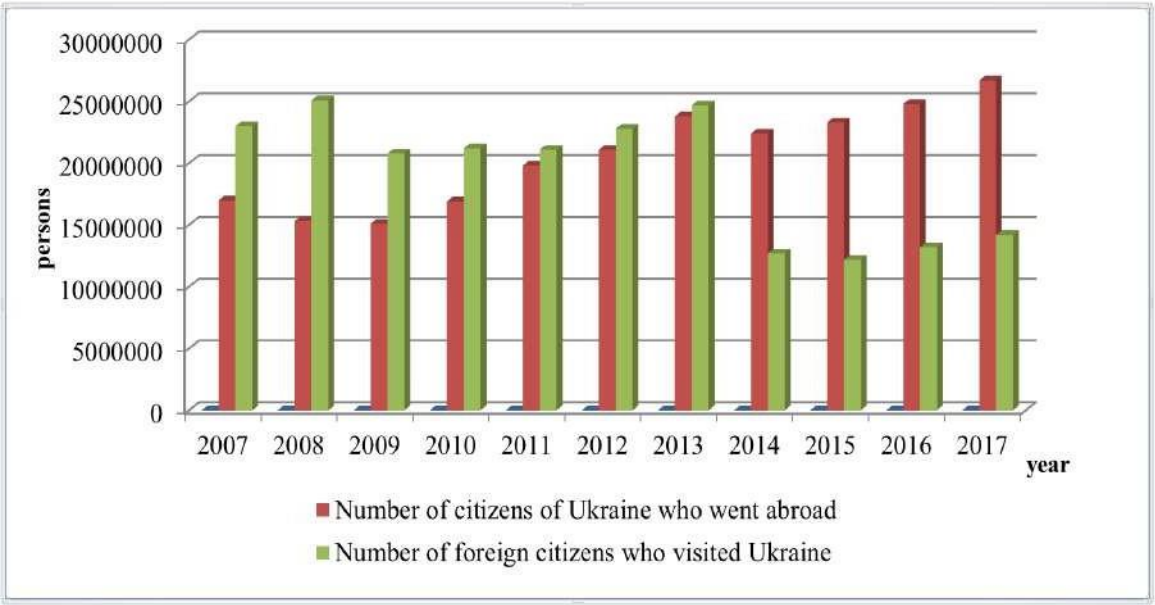

Fig. 1. Dynamics of tourist flow of Ukraine for the period 2007-2017, persons (Official site of the State Statistics Service of Ukraine, 2018)

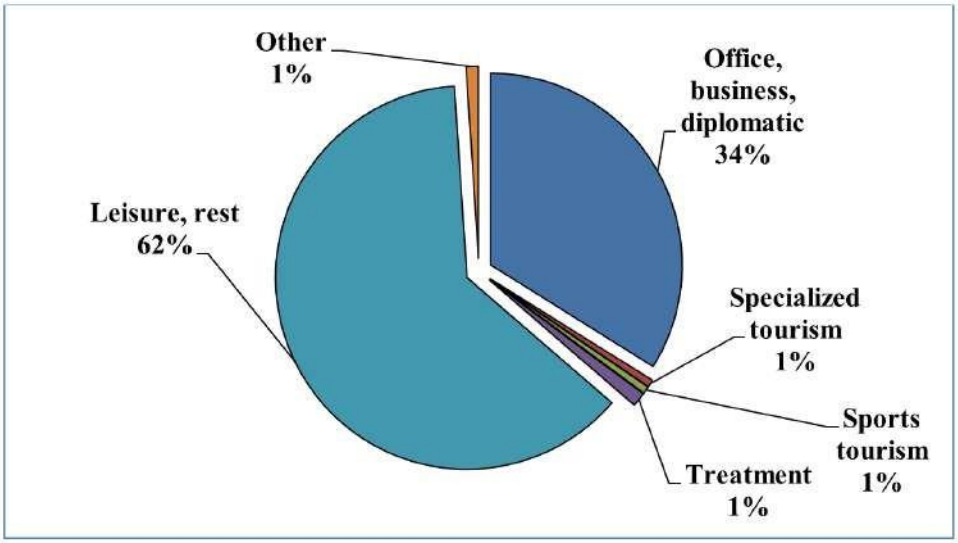

Fig. 2. The structure of the outflow of citizens of Ukraine for travel in 2017, persons (Official site of the State Statistics Service of Ukraine, 2018, UNWTO Tourism Highlights, 2018, World Travel and Tourism Council, 2018)

representatives of Europe and the CIS countries with a share of 21%, the third place - by representatives of the African continent with a share of 18%.

The geographical structure of imports to European countries is 35%, and to the African region - 7%, ranking second and third, respectively. Representatives of the CIS countries account for only 2.5% of total imports of tourist services to Ukraine (World Travel and Tourism Council, 2018).

An additional balance of bilateral trade in tourist services of Ukraine was with the CIS countries, America, as well as Australia and Oceania.

Important tasks of economic theory and practice are to identify and regulate the most important macroeconomic indicators of socio-economic development of the country, to identify trends and factors that affect their scale (Pavlenko, 2013).

Тому функціонування економіки країни в цілому оцінюється на основі чітко визначених показників, що дозволяють оцінити її динаміку. За останні три роки темпи зростання були позитивними (рис. 5). Therefore, the functioning of the country's economy as a whole is assessed on the basis of clearly defined indicators that allow us to assess its dynamics. Over the past three years, growth rates have been positive (Fig. 5).

2017 can be called the year of tourism development in Ukraine: the flow of tourists is growing rapidly, and the number of permits for sale, according to the State Statistics Committee of Ukraine, increased by 36%.

Also, one of the favorable conditions for the development of tourism in Ukraine was the adoption of a visa-free regime with EU countries. The tourism

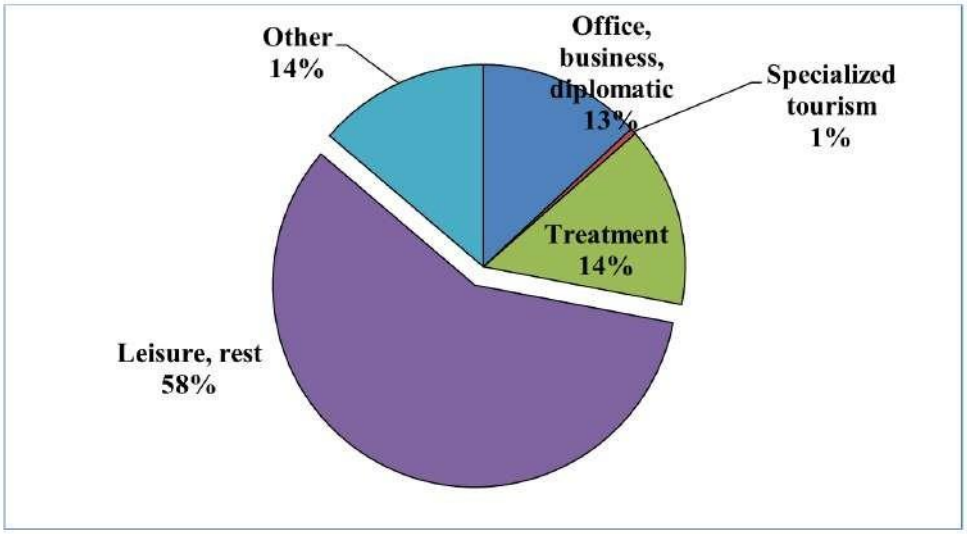

Fig. 3. The structure of the inflow of citizens of Ukraine for the purpose of travel in 2017, persons (Official site of the State Statistics Service of Ukraine, 2018)

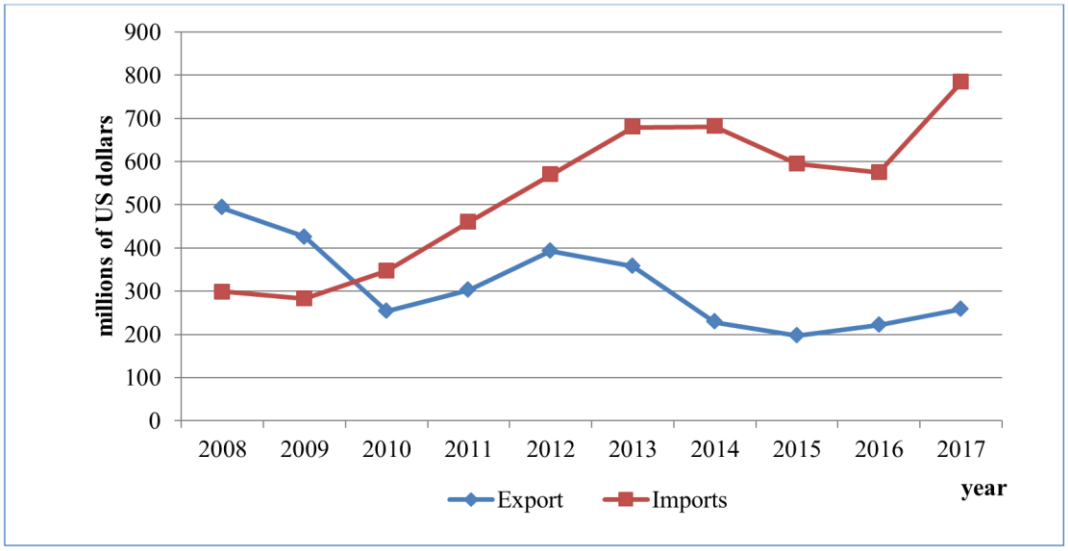

Fig. 4. Dynamics of change in export-import of tourist services of Ukraine for the period of 2008-2017, millions of US dollars (Official site of the State Statistics Service of Ukraine, 2018)

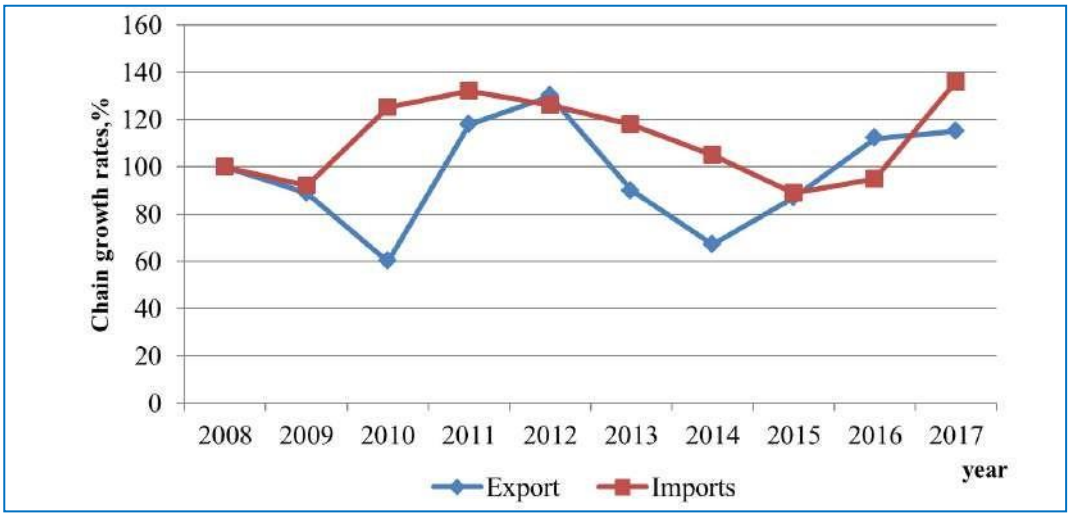

Fig. 5. Dynamics of change in the chain growth rates of exports and imports of international tourist services of Ukraine for the period 2008-2017, % (Official site of the State Statistics Service of Ukraine, 2018)

market is gradually recovering after the 2014 crisis, and Ukrainians are starting to visit EU countries.

When analyzing the tourist market of Ukraine, it is advisable to assess both the number of tourism entities (Fig. 6) and their performance.

Thus, in 2017, the number of Ukrainian tourism entities - legal entities and individuals-entrepreneurs - was 3469 units, which is 40 units less than in 2016. In the structure of all tourist entities, the largest number falls on travel agencies, the share of which exceeds 80% of the total number of legal entities. The maximum development of the tourism industry can be observed in 2012 and 2013, which can be explained by the holding of the European Football Championship in 2012, after which there was a sharp decline in both the number of businesses and reduced incomes. And in 2017, the number of legal entities decreased by 6%. At the same time, the number of legal entities engaged in tourism in 2017 compared to 2016 increased by 58 units.

The number of tourists - citizens of Ukraine, who were served by tour operators in 2017, was more than 2.7 million people (which is 8% more than in 2016), foreign tourists - almost 40 thousand people (in 2016, respectively, 35 thousand persons). For the vast majority of tourists (85%) the main purpose of the trip was to organize leisure and recreation. Revenue from the provision of tourist services to businesses is presented in Fig. 7.

From Fig. 7 we see that, despite a certain decrease in the number of tourism entities, in 2017 there was a significant increase in income of legal entities engaged in the provision of travel services (including tour operators, travel agents and businesses engaged in excursion activities in this category) by 60% compared to 2016. Positive changes were also

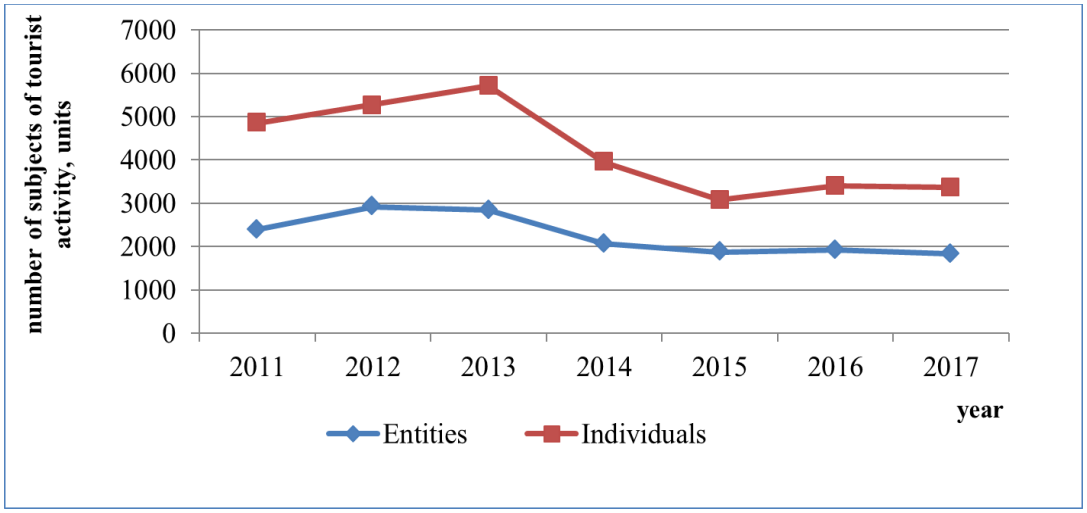

Fig. 6. Dynamics of change of subjects of tourist activity in Ukraine, units (Official site of the State Statistics Service of Ukraine, 2018)

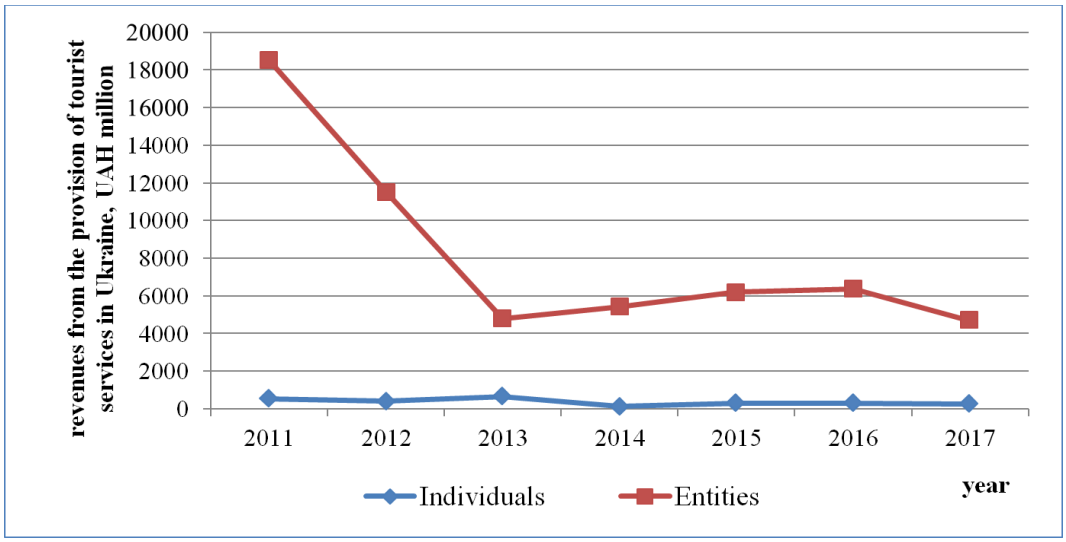

Fig.7. Dynamics of change in revenues from the provision of tourist services in Ukraine, UAH million (Official site of the State Statistics Service of Ukraine, 2018)

characterized by the income of individuals (travel agents and organizations engaged in excursion activities), which increased by more than 25% compared to 2016.

At the same time, the increase in revenues from the provision of tourist services during the study period is associated with an increase in both the cost of tourist services and an increase in the number of vouchers sold (State Statistics Service of Ukraine).

Since the development and income of tour operators that they receive directly depend on the number of tourists served, it is advisable to analyze the number of tourists served by tour operators in Ukraine during 2011-2017 (Fig. 8).

Citizens of Ukraine who went abroad used the services of tourism entities the most. Like the above-mentioned tourist flows in Ukraine, the number of tourists served by tour operators has the same dynamics as peak (2013), decline (2014) and development (since 2015).

The study identified the leaders of tour operators in the number of tourists served, based on the ratings of various marketing companies and reviews of tourists (Table 1 and Table 2).

It is also advisable to consider the rating of tour operators in the most popular destinations - Turkey and Egypt among Ukrainian tourists in 2017 (Fig. 9). Ukraine ranked 7th among the leading countries in the number of tourists who visited Turkey in 2017. During this period, this destination was chosen by 1,212,644 tourists, which is 23% more than in the same period of 2016.

Slightly different positions are occupied by tour operators in the Egyptian direction (Fig. 10).

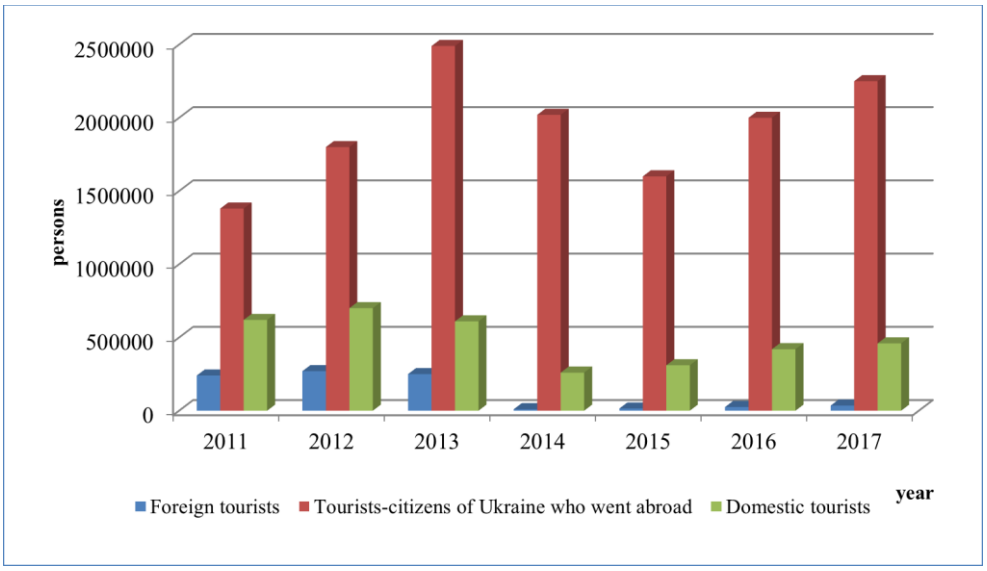

Fig. 8. Dynamics of changes in the number of tourists served by the subjects of tourist activity of Ukraine, persons (Official site of the State Statistics Service of Ukraine, 2018)

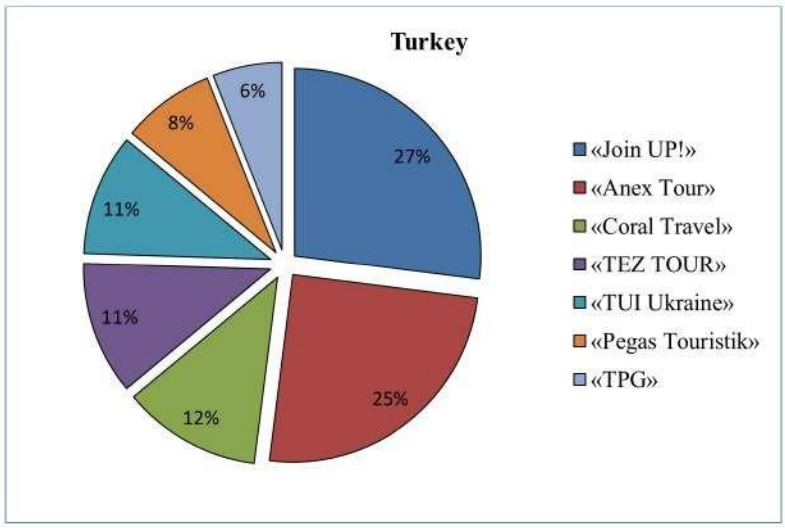

Fig. 9. Tour operators-leaders in sales of tours to Turkey, % (Official site of the State Statistics Service of Ukraine, 2018)

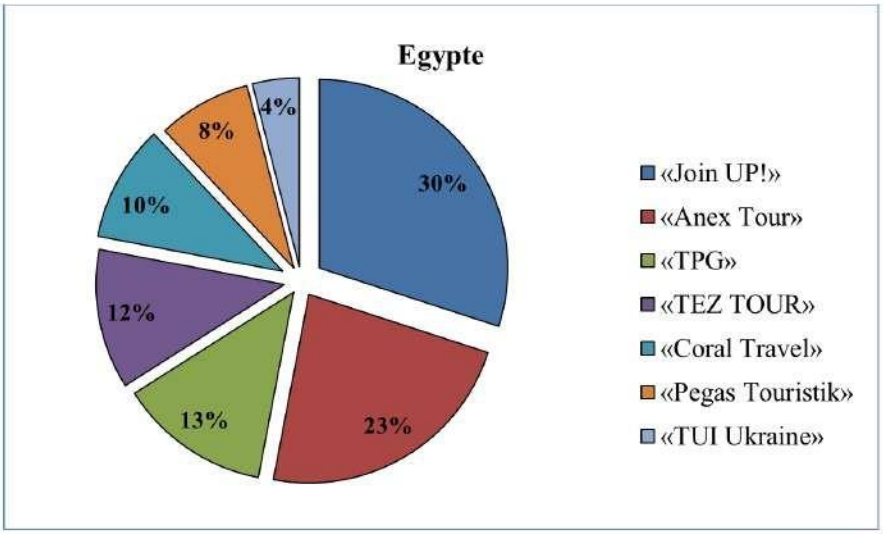

Fig. 10. Tour operators-leaders in sales of tours to Egypt,% (Official site of the State Statistics Service of Ukraine, 2018)

Table 1. Rating of tour operators by the number of served tourists (Official site of the State Statistics Service of Ukraine, 2018)

Place	Tour operator	Number of tourists who used the services of a tour operator, thousand people
1	«Join UP!»	500
2	«Anex Tour»	374
3	«TPG»	300
4	«Coral Travel»	170
5	«Pegas Touristik»	130
6	«TEZ TOUR»	120
7	«TUI Ukraine»	100
8	«Akkord tur»	77
9	«Mouzenidis Travel»	54
10	«Feieriia»	50

Table 2. Rating of tour operators according to tourist reviews (Official site of the State Statistics Service of Ukraine, 2018)

Place	Tour operator	Number of positive reviews
1	«Akkord tur»	5124
2	«TPG»	5059
3	«Feieriia»	5008
4	«Alf»	3494
5	«TEZ TOUR»	2550
6	«Hamaliia»	2055
7	«Mouzenidis Travel»	2030
8	«Pegas Touristik»	2010
9	«Join UP!»	1734
10	«TUI Ukraine»	1679

Conclusions. Analyzing the situation on the world market of tourist services in Ukraine, we can conclude that one of the favorable conditions for tourism development in Ukraine was the adoption of visa-free regime with EU countries, the tourist market gradually recovered after the crisis of 2014, and Ukrainians began to travel to Europe. But we can also single out the factors that hindered the development of tourism in this period, such as a decrease in incoming tourist flows due to territorial, political changes and a sharp rise in exchange rates. Representatives of the Asian continent rank first in exports and imports of international tourist services in Ukraine with a share of 32% and 52%, respectively. In terms of exports, the second place is occupied by representatives of Europe and the CIS countries with a share of 21%, the third place - by representatives of the African continent with a share of 18%. It can now be argued that, as a result of the global pandemic, the market for travel services has come to a near halt.

2017 can be called the year of tourism development in Ukraine: the flow increased rapidly, and the number of permits for sale, according to the State Statistics Committee of Ukraine, increased by 36%. Citizens of Ukraine who went abroad used the services of tourism entities the most. It is established that the largest number of tourism entities is concentrated in the cities of Kyiv, Dnipropetrovsk, Kharkiv and Odessa regions. The most popular destinations for tourists from Ukraine are Egypt and Turkey. Join UP!, Anex Tour, Coral Travel, TEZ Tour and others are the tour operators that are the leaders

in selling tours to these countries. Of course, tourism is one of the priority parts of the economy of any country, including Ukraine, so state support for the tourism industry is extremely important, and research on the tourism market is always relevant, regardless of the economy of a country or region.

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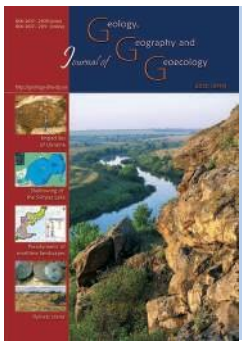

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The Ilyinets meteorite crater - geological structure unique in Europe and a promising destination for international tourism

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Abstract. The Ilyinets meteorite crater is located in Lypovets and Ilyinets districts of Vinnytsia region. It is accessible for examination in quarries near Luhova and Ivanky villages in the Sobok River valley. This site currently has the status of a geological natural landmark of local significance. The crater appeared as a result the impact of a meteorite on Precambrian surface of the Ukrainian Shield 445 million years ago. The impact of the explosion caused the formation of a typical ring structure about 8.5 km diameter and 600-800 m deep. The denudation level in the crater area is estimated at about 300-400 m. Thus, the preserved part of the crater has a diameter of about 3.2 km and is 400 m deep. Target rocks are represented mainly by granitoids of the Haisyn (Sobite) complex. The meteorite crater consists of impactites: shock-melt rocks, impact bombs, allogenic and authigenic breccia (suevite, tagamiteetc). Genesis of impactites is confirmed by the findings of stishovite, koesite, impact-type diamond, the presence of metallic and silicate spherules, planar structures in quartz, feldspars and other characteristic features. Overlap rocks are represented by sporadically distributed Devonian and widespread Quaternary sediments. Their thickness reaches 13 m, and it decreases to 3 m in the Sobok River valley. The Ilyinets meteorite crater is the most representative in Europe because it is easily accessible for examination and study, and available for sampling. Undoubtedly, it is a promising unique geological object that can attract attention of tourists around the world, as well as geoscientists interested in studying unique natural sites and phenomena in Europe and on the Earth in general.

Keywords: *Ilyinets meteorite crater, impactites, suevite, tagamite, impact bomb, tourism*

Іллінецький метеоритний кратер – виняткова геологічна споруда Європи та перспективний об'єкт міжнародного туризму

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Анотація. Іллінецький метеоритний кратер розташований в центральній частині України, на території Липовецького та Іллінецького районів Вінницької області. Він доступний для огляду в кар'єрах поблизу сіл Лугова та Іваньки в долині річки Собок. Зараз ця ділянка має статус геологічної пам'ятки місцевого значення. Кратер утворився внаслідок падіння метеориту на докембрійський фундамент Українського щита 445 мільйонів років тому. Імпактний вибух спричинив утворення характерної кільцевої структури діаметром близько 8,5 км та глибиною 600-800 м. Рівень денудації в районі кратера оцінюється приблизно в 300-400 м. Таким чином, збережена частина кратера має діаметр близько 3,2 км і глибину 400 м. Породи мішені представлені переважно гранітоїдами гайсинського (собітового) комплексу. Метеоритний кратер складається з імпактитів: ударно-розплавних порід, бомб, аллогенних та аутігенних брекчій (зювіти, тагаміти). Генезис імпактитів підтверджується знахідками стишовіту, коеситу, імпактних алмазів, наявністю металевих і силікатних сферул, планарних структур у кварці, польових шпатах та іншими мінералого-петрографічними ознаками. Породи перекриття представлені локально розвиненими девонськими та повсюдно поширеними четвертинними відкладами. Загалом потужність порід перекриття сягає 13 м, а в долині річки Собок вона зменшується до 3 м. Метеоритний кратер Іллінці є найбільш репрезентативним у Європі завдяки його доступності для огляду та вивчення, можливості відбору проб, значної кількості архівних та опублікованих геолого-

геофізичних матеріалів. Безперечно, це унікальний геологічний об'єкт, який може привернути увагу туристів по всьому світу, а також геологів, зацікавлених у вивченні унікальних пам'яток природи та явищ у Європі зокрема та на Землі загалом.

Ключові слова: Іллінецький метеоритний кратер, імпактити, зювіти, тагаміти, імпактні бомби, туризм

Introduction. The Earth's surface preserves the "imprints" left by large meteorites - craters. We can assume that the famous meteorite craters are the consequences of only part of the impact events that occurred during the history of the planet. After all, under certain conditions, during the collision with the Earth, the cosmic body can form furrowed craters of insignificant depth, which quickly disappear due to the erosion and lithogenesis processes. Most known craters do not contain residues of meteorite matter. The rocks formed as a result of meteorite impact are often similar to volcanic or metamorphic, which makes it difficult to diagnose their origin.

According to modern data, about 20 thousand tons of meteorite matter enters the Earth's atmosphere annually. More than 50 tons of space material, including meteoritic dust, falls every day. The share made up by large debris (from several kilograms to a ton) is approximately 100 tons per year. In historical times, only a comparatively small amount of cosmic debris up to 1.0-1.5 tons was recorded falling to Earth. Small (several tens of meters) craters were formed as aresult.

Collisions of the Earth with celestial bodies, the size of which exceeds a few kilometers in diameter, occur on average once every million years. In this case, impact craters are formed. One of the authors of the new global plate tectonics Robert S. Dietz in 1960 proposed the special term "astrobleme" to indicate. Today this, the term is hardly used by scientists in the world. On celestial bodies, where there is no atmosphere (Mercury, Moon, Phobos, Deimos, etc.), meteorite craters, regardless of the time of formation, are stored intact. The reason for their destruction can be only the fall of later meteorites.

There are two types of meteorite craters: impact - less than 100 m in diameter and explosive - more than 100 m in diameter. The first one is the result of small meteorite falls. The second type occurs when the Earth collides with large-sized cosmic bodies. During a collision with the Earth's surface, the meteorite`s movement sharply slows down. The rocks in the place of fall (target rocks) begin to move rapidly under the influence of a shock wave. The shock wave covers the hemispherical region below the planet's surface and also moves in the opposite direction along the body of the meteorite. The meteorite is destroyed completely as a result of abrupt change in stretching and compression. The shock wave causes a sharp rise in temperature (over 3000 °C) and pressure (over 5 million atmospheres).The rocks heat up (partially melt) and in the center of the collision partly evaporate. The rocks formed after cooling and solidification at the bottom of the crater can be enriched with meteorite-specific chemical elements - iridium, osmium, platinum, palladium, nickel and chromium.

The plasma formation, which occurs in the process of instant evaporation of part of the matter, is accompanied by an explosion. As a result, the target rocks fly away in different directions and the bottom of the crater descends. At the bottom of the newly formed crater, there is a depression with steep edges that collapse due to gravity. The bottom of the crater is covered with rock debris thrown as a result of the collision. Breccia, a layer of debris cemented with the same material, ground to sand and dust, is formed. The impact melt buried beneath the breccia layer begins to solidify rapidly, completing the crater formation process. The processes of the meteorite craters' formation on the Earth's surface are described in detail in the works of E.P. Gurov (Kelley and Gurov, 2002; Gurov, 2002).

The meteorite crater consists of impact rocks called impactites: shock-melt rocks, impact bombs, allogenic and authigenic breccias (Valter et al., 2000; Kats et al., 1989).

One of the most famous, well-researched and best-preserved meteorite craters on the Earth's surface is Arizona Crater (also called the Berringer Crater). It is located in the desert of Arizona (USA), near Winslow. The crater formed about 50 thousand years ago as a result of a collision with the Earth of iron-nickel meteorite with a diameter of 50-70 m (Artemieva and Pierazzo, 2009; Roddy and Shoemaker, 1995). The energy released during the collision ranged from 1 to 60 megatons (Kring, 2017). The meteoritic origin of the crater is evidenced by the inclusion in the rocks of the bottom of iron-nickel alloys: kamacite and taenite, which are typical of iron meteorites. Coesite and stishovite, which are formed under extremely high pressures and temperatures that occur only during high explosions, have also been identified (Shoemaker, 1987).

The Ilyinets crater is one of the most famous in Ukraine, a generally recognized structure and is on the list of confirmed impact structures found on the Earth's surface. The Ilyinets structure has been studied by scientists since the mid-19th century. In the 1970s, geological, mineral-petrographic and geochemical evidence of its meteoritic origin was found. In 2017, the Ilyinets Impact structure was granted

conservation status as a natural geosite of local importance – «the Ilyinets Crater» (the nature reserve of the Ilyinets district of Vinnytsia region). The first geological excursion to this structure took place in 1984 within the framework of the International Geological Congress.The purpose of the article is to attract the attention of geoscientists and tourists from around the world to the Ilyinets meteorite crater as a unique natural landmark and phenomena in Europe and on the Earth as a whole.

Structure of meteorite craters. Earth's meteorite craters are similar to those of the Moon, Mars, Mercury and other planets. They have a rounded shape, but their diameter is much smaller (for example, the Walgall structure on the surface of Callisto reaches 3000 km in diameter; Gurov and Gurova, 1987). Meteorite craters are diagnosed by the characteristic shaft, which acts as a rise around the depth, the presence of a central lift - a slide, a distinct radial-annular arrangement of cracks, the presence of fragmented rocks and other features.

An annular bar is a structure that surrounds the crater. The bar profile is usually asymmetrical: its inner slope is steeper than the outside. The volume of a circular bar rock for meteorite craters is usually 20-40% of the displaced rock volume.

The bottoms of the craters in the section have different shapes (flat-bottomed, cup-shaped, etc.). Their morphology is complicated by the increase in diameter. For example, the bottoms of large craters are complicated by central mound. The central mound, or central peak, is an obligatory structure that is formed in craters with a diameter of 5 to 50 km. It arises according to the laws of mechanics due to the elastic recoil of the target rocks' surface. The central mound isn't formed in craters with a diameter of more than 50 km, but such craters have central annular elevations.

Unlike the lunar craters that form and develop in a non-atmospheric environment, terrestrial impact structures immediately after their formation are destroyed by exogenous processes. Meteorite craters in Ukraine are practically not reflected in modern relief as they have formed tens and hundreds of millions of years ago. The Ilyinets meteorite crater has been affected by denudation processes for 445 million years. Therefore, as a result of erosion-denudation processes, the present size of this structure is much smaller than its original parameters. It is assumed that the size of the surface denudational section of the Ukrainian Shield in the Ilyinets structure area is approximately 300-400 m (Gurov et al., 1998).

According to the geomorphological views, the modern relief of the layer accumulative plain of the Ilyinets district began to form in the Paleogene-Neogene period. Ultimately, the modern relief was formed in the late Pleistocene, when the modern valley and complex of alluvial terraces of the Sobok River were formed.

Object of research is Ilyinets Meteorite Crater. 8 meteorite craters are known in Ukraine (Fig. 1) (http://www.passc.net; Valter, 2000; Kelley and Gurov, 2002; Gurov and Gozhik, 2006; Gurov and Nikolaenko 2017; Gurov and Nikolaenko 2017; Kats et al., 1989). The Ilyinets meteorite crater is explosive and a result of the fall of a cosmic body into the Ukrainian Shield territory 445 million years ago. As a result of the collision, a circular structure with a diameter of about 8.5 km and a depth of 600-800 m was formed. The primary relief of the meteorite crater was changed by denudation exogenous processes. At the current level of the denudation section, the outer diameter of the area of impactites' distribution is about 3.2 km. Unlike other impact structures in Ukraine, Ilyinets is not covered by a sedimentary cover and is characterized by the presence of shifted impact structures which were created as a result of the impact and explosion of the meteorite during its contact with target rocks, mainly Paleoproterozoic granitoids.

History of geological research. Until the middle of the last century, geological studies of the watershed of the Sob and Southern Bug rivers were fragmentary. The first information about the geology of the area appeared in the 1930s in works of Eichwald E.I. and Jakovitsky I.A. In 1851 Feofilaktov K.M. carried out geological surveys in the Sob river valley and identified volcanic rocks of the Ilyinets structure, which, in his opinion, were exposed to high temperature and pressure. According to petrographic studies (Tarasenko V.E, 1898), these rocks were interpreted as tuffs. From 1892 to 1915 the basins of the Ros and the Southern Bug River were explored by Sokolov M.O., Tarasenko V.E., Laskarev V.D., Luchitsky V.I., Tutkovsky P.A. They focused on stratigraphy, geomorphology and tectonic processes.

Systematic studies of this territory began in the second half of the twentieth century. During the large-scale geological mapping in 1956 Zholdak A.I., Vinogradov G.G and Ryabenko V.A. suggested the early Paleozoic age of the Ilyinets structure rocks. For the first time, they outlined the area of the development of this rock. It was also determined that it was located at the junction of Dzhuryn–Nemyriv–Ipyshets, Verkhniy Bug and Bratslav–Ladizhen regional faults. (Radzivill et al., 1986; Vinogradov et al, 1973).

In the early 70s, Masaitis V.L. (Masaitis, 1973; Masaitis, 1974) and Valter A.A. (Valter and Riabenko, 1976; Valter and Ryabenko, 1977) reported about the presence in the rocks of the Illinet structure of signs

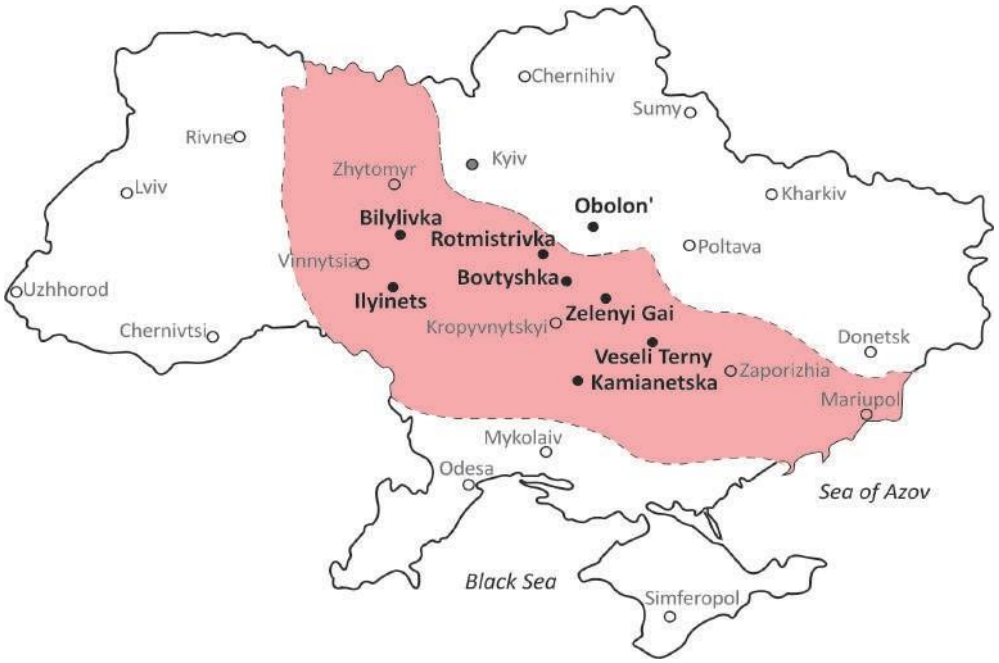


Fig. 1. Meteorite craters within the Ukrainian Shield (based on materials from Kryvodubskyi et al., 2004; Gurov et al., 2017).

of shock metamorphism. This new data led to a revision of ideas about the genesis of the structure and its attribution to the impact. A new concept of structure formation was supported by York Yu., G.K. Eremenko G.K., Polkanov Yu.O. and Nikolskyi A.P. In the 1980s, the ideas of the impact genesis of similar structures within the Ukrainian Shield were covered in the monographs and publications of Valter A.A., Ryabenko V.A.(1980, 1981, Valter et al A.A., 1982), Masaitis V.L.(1979, Masaitis et al. 1980), Gurov E.P. (1980, 1983) etc.

A logical consequence of the purposeful research of Ukrainian scientists and geologists was the discovery of impact type diamonds in the rocks of the Ilyinets structure. According to the results of geophysical researches, the Ilyinets gravimagnetic anomaly was revealed, the configuration of which was further detailed (Entin, 2012).

In the 1990s, the geological study of the Ilyinets structure continued at the Institute of Geological Sciences of the NAS of Ukraine under the direction of Gurov E.P. (Gurov et al., 1998). Valter A.A. published works devoted to the study of impact diamonds of Ukrainian impact structures (Valter, 1997, 1998, 2005).

Additional well drilling in 2010 (mapping works in the frame of GDP-200, M-35-XXX (Gaisyn)) gave new geological and geophysical data, as well as core materials the further petrographic and mineralogical study. In 2012, the PDRGP Pivnichgeologia together with the Institute of Geophysics of the NAS of Ukraine investigated the geophysical features of the structure and genesis of the Ilyinets structure (Entin et al, 2013). In 2015, State Enterprise "Ukrainian Geological Company" issued a set of maps on a scale of 1:200 000 territories of sheet M-35-XXX (Gaisyn). During these works, the geological and geophysical material were summarized, the contours and geological structure of the Ilyinets impact structure were specified (Prykhodko et al. 2013).

In total, within the Ilyinets structure, there are 6 outcrops of impact rocks (including 3 quarries), 58 wells, 7 of which are over 200 m deep.

Geological structure of the area. The territory of study is located on the border of Lypovets (Ivanky village) and Ilyinets (Lugova village) districts of Vinnytsia region. Following the current physical and geographical zoning, it belongs to the Podilly-Prydniprovia region of the forest-steppe zone of Ukraine. From the geomorphological point of view, the area of the Ilyinets structure is located within the layer accumulated sloping hilly-undulating alluvial-delta plain formed on Paleogene-Neogene sediments. The territory is divided by river valleys. Altitude elevations (relative to sea level) vary from 280-290 m in watersheds to 210-220 m in river valleys.

The Ilyinets meteorite crater is located 10 km west of Ilyinets in the Vinnytsia region in the Sobok valley. Visible fragments of the crater represented by typical impact rocks of various structural and textural types. These rocks are disclosed in the outcrops and quarries on the right bank of the Sobok River, on a 2 km long section between the villages of Ivanyki and Lugova.

Geological characteristics of target rocks. The Ilyinets meteorite crater is located on the boundary of

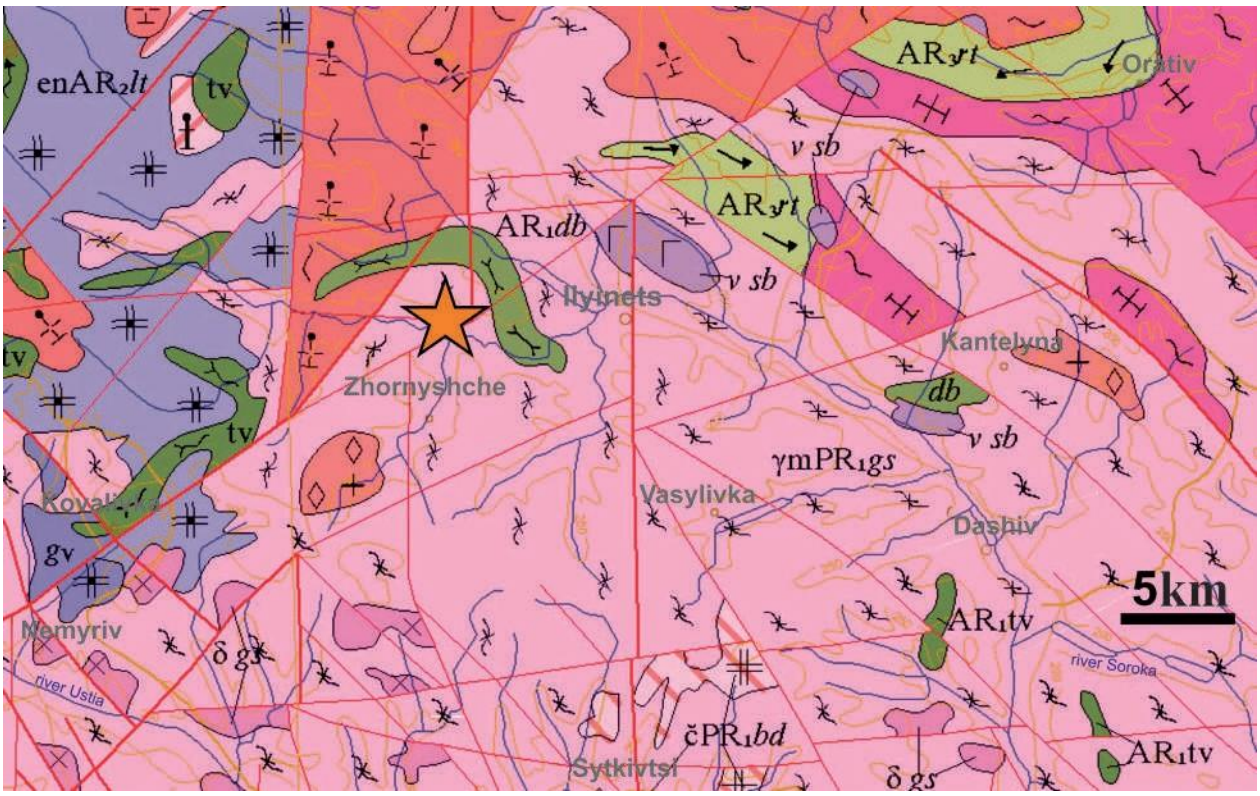


Fig. 2. Geological map of the Ilyinets meteorite crater (according to the materials of the State Enterprise "Ukrainian Geological Company"). Light pink indicates the granitoids of the Gaisyn (Sobite) complex; purple - enderbites of the Lityn complex, red - granitoids of Berdychiv complex and pink - granitoids of Uman complexes. The metamorphic rocks: light green colour - the Tyvriv sequence, green - undivided Dniester-Bug series.

two adjacent megablocks of the Ukrainian Shield- the Dnister-Bug and the Ros-Tikych (Koreliatsiina…, 2004). In its geological structure the main role is played by: Mesoarchaean enderbites of the Lityn complex and Paleoproterozoic granitoids of the Gaisyn, Uman and Berdychiv complexes (Fig. 2). The enderbites contain the remains of the crystalline schist and calciphyre of the Tyvriv sequence of the Dniester-Bug series, whereas among the granitoids - numerous, different-sized xenoliths (and remains) of undivided metamorphic formations of the Dniester-Bug and Rosyn-Tikich series are noted. The target rocks are the most common in the area of the Gaisyn (Sobit) complex granitoids.

This view was supported by Bezborodko M.I., Polovinkina Yu.I., Tkachuk L.G., Usenko I.S., Goodwill M.M. At the same time, Slenzak O.I. said for the first time that the sobite has an intermediate position between the charnokite and the migmatites of the Kirovograd complex. Lisak A.M. and Pashchenko G.M. believe that the sobite forms not one, but two separate formations, namely sobite (diorite, granodiorite, plagiogranite) and Uman (biotite porphyry granite). Shcherbakov I.B. proposed to define the Gaisyn complex, which consists of the association of genetically united rocks from charnokite to normal two-feldspar granites: diorites - quartz diorites - granodiorites (tonalites) - amphibole-biotite granites - biotite granites - pink aplite-pegmatoid granites (Shcherbakov, 1975; Shcherbakov, 2005). Usually, all kinds of rocks are usually present within one outcrop. So it is very difficult to determine any patterns in their spatial distribution. These granitoids are spread over an area of over 4000 km^2 and extend along the valleys of the rivers Sob, Southern Bug, in the upper reaches of Ros and Roska. Structurally, they are located in the area of the junction of the Rosyn-Tikych and Dnister-Bug megablocks.

The rocks of the complex are massive, from medium to coarse-grained, even-grained and porphyric. In the outcrops the rocks looks like typical magmatic formations. This impression is intensified by the presence of diverse, often rounded, xenoliths. They are represented by the rocks of the Dniester-Bug series: pyroxene-containing amphibolites, two-pyroxene-plagioclase crystalline schist, calciphyre, ferruginous quartzites, and rarely garnet-biotite plagiogneisses. In granites porphyroblasts are represented by potassium feldspar, and in the more basic rocks - plagioclase with a characteristic steel-grey, almost black colour. Aplite-pegmoid granites contain typically granulite blue-grey quartz.

To determine the time of the Gaisyn complex formation, the monazite from the granite quarry

Fig. 3. Rocks from a quarry in Nyzhcha Kropyvna village: 1) porphyry-shaped granite; 2) xenoliths of crystalline shale in granites (Stepanyuk et al., 2017)

in the Nyzhcha Kropyvna village on the left bank of the Southern Bug River was dated by the uranium-lead isotope method (Stepaniuk et al., 2017). The quarry is located 25 km southwest of Ilyinets Crater. The dated amphibole-biotite inequigranular grained (to porphyropic) granites (Fig. 3) have gradual transitions with different grades of K-feldspathization diorite-like rocks and granodiorites. The studied rocks contain numerous crystalline xenoliths, rarely amphibolites. The sizes of the crystalline schist bodies range from a few centimeters to several meters, and their shape is usually angular. The whole rock association looks like eruptive breccia, the cement of which is pink porphyry-like granite similar to the Uman one.

The Gaisyn complex granites were formed about 2.05 billion years ago (Stepaniuk et al., 2017). Due to the fact that the monazite crystals are spatially confined mainly to the microcline, the obtained age value characterizes the granite formation process sufficiently. The obtained isotope date is in good agreement with the time of formation of two-feldspar granites of the Uman complex of the Rosyn-Tikiych megablock.

Geology of the Ilyinets meteorite crater. The Ilyinets meteorite crater is the oldest and most eroded crater among the known impact structures of the Ukrainian Shield (Fig. 1). In its section, four major rock complexes are distinguished (Prykhodko et al., 2013): basement, coptogenic, filling and overlaps (Fig. 4). In the lower and lateral parts of the crater are rocks of the basement complex. They are represented by an autogenous breccia - brecciated rocks that have undergone shock metamorphism. With depth, they gradually turn into cataclased rocks and gradually into undisturbed rocks. The basement complex is overlain by a coptogenic one. The coptogenic complex, which was created by the explosion, consists of allogeneic breccia and impactites (from the bottom up). Allogeneic breccia is a displaced rock that is bedded on an authigenic breccia. It consists mainly of altered metamorphism of the target rocks fragments.

The target rocks were the above-described granitoids of Gaisyn type. It is likely that the crystalline rocks had a clayey weathered crust since allogeneic breccia contains solid inclusions of baked clay.

Impactites complete the coptogenic complex and, depending on the glass content, are divided into suevite (glass up to 75%) and shock-melt rocks (glass up to 100%). Allogenic breccia, which almost doesn't contain glass, accounts for more than 60% of the volume of coptogenic rocks. The suevite lies on it with allogenic lenses and fragments of autogenous breccias. There are single shock melt lenses among the suevite, with a thickness from a few centimeters to 46 meters. These rocks are sometimes related to tagamites by analogy with the rocks found near Tagami Mountain in the Popigai River Basin.

The coptogenic complex rocks are overlain by the lenses of the Devonian mudstone and eluvium, formed of a cemented mass of suevite, fragments of mudstone and brecciated rocks of the foundation. One of the lenses of mudstone reaches 3.7 km in length and is oriented in the latitudinal direction (Fig. 4).

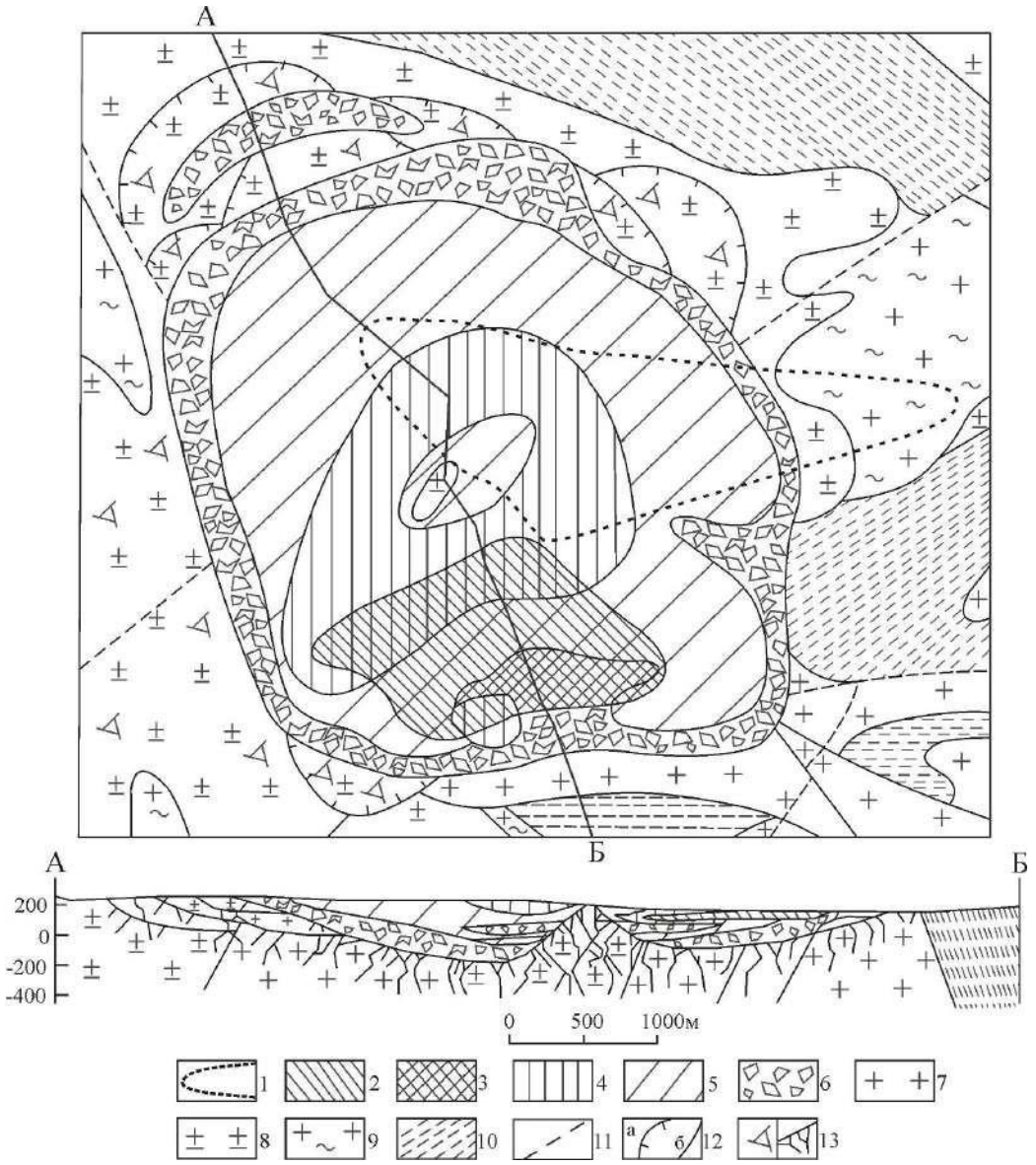


Fig. 4. Schematic geological map (without Cenozoic sediments) and the section of the Ilyinets impact structure (Masaitis et al., 1980).

Symbols: 1 - boundaries of the area of distribution of Devonian clays, mudstones, and siltstones; 2, 3 - distribution of shock-melt rocks (2 - under suevites and Cenozoic sediments. 3 - under Cenozoic sediments); 4 - crystal-vitroclastic suevites; 5 - vitro-crystal-loclastic suevites; 6 - allogeneic breccia; 7 - aplite-pegmatoide granites; 8 - biotite granites; 9 - diorites, quartz diorites, granodioites (tonalites), plagiogranites; 10 - gneisses and crystalline schist; 11 - faulting of uncertain morphology; 12 - predicted drifts (a - on the map, b - on the section); 13 - shock fracture (a - on the map, b - on the section).

The Neogene (Miocene) rocks lie on the filling complex. They are represented by secondary kaolins, clays, sands, on which the Quaternary deposits formed. The rocks' average volume of the overlapping complex at the watershed (in the central part of the structure) is 13 m, in the valley of the Sobok River, it decreases to 3 m.

Mineral-petrographic features of impactites. Rocks and minerals undergo impact metamorphism and shock melting in the process of impact cratering. The impact nature of rocks and structures formed by them is considered to be confirmed by the presence of signs of shock-metamorphic origin (Gurov, 2002). The most important features of shock metamorphism are the short duration of its influence and the creation of ultrahigh pressures and temperatures that are not reached in endogenous processes.

A.A. Valter (Valter et al., 1982) found that the rock and mineral composition of an authigenic (unmoved) breccia fully corresponds to the foundation rocks' composition, which lies below, and in the central part of the structure, small brittle material accounts for approximately 50% of the composition of the authigenic breccia.

An allogenic breccia is a relocated impactite. It consists of target rock fragments, cemented with a

fine-grained mass of minerals grains with signs of impact metamorphism of varying degrees. The allogenic breccia in the Ilyinets Crater lies, with a gradual transition, on authigenic breccia and fills an annular trough with a diameter of approximately 3.2 km. Unlike authigenic, allogeneic breccia is a heterogeneous accumulation of clumps and fragments of various compositions, which indicates the removed nature of these formations.

In the cross-section of the Ilyinets structure from the bottom up, the size of the fragments in allogenic breccias gradually decreases, separate particles and pancake-like fragments of glass appear with the inclusion of fragments of rocks and minerals with clear signs of shock metamorphism. The rocks change into suevites (Fig. 5), which in unaltered form have a grey colour with a greenish or bluish tone. The colour of the suevites changes from pale yellow to brown as a result of weathering. These rocks are strong, breccia texture, sporadically porous and cavernous due to glass alkalinisation. The yellow-white molten glass fragments of the various forms (up to 8 cm) can be observed against the background of pale-yellow fine-grained mass. The suevites contain a significant amount of brecciated granite rubble, rarely gneiss sizes from 1-3 mm to 10-20 cm. The fragments of minerals are represented by feldspars, quartz, amphiboles, and pyroxenes, sometimes garnet. These fine-grained minerals also form the cementitious mass of the rock. In addition to a glass of irregular shape, the suevites contain the inclusion of «aerodynamic» shape, the so-called «bombs» (Gurov, 2009). Their sizes vary from 1-2 to 10-13 cm in diameter; form - droplet-shaped, spherical, sometimes spindly. There are peculiar longitudinal furrows and ribs on the sur- face. Usually «bombs» have a zonal structure: the inner core is composed of relicts of clay or crystalline rocks; the outer shell has a crystalline structure with inclusions of fine-grained fragments; contacts with the core are clear, irregular, wavy or toothed (Fig. 6).

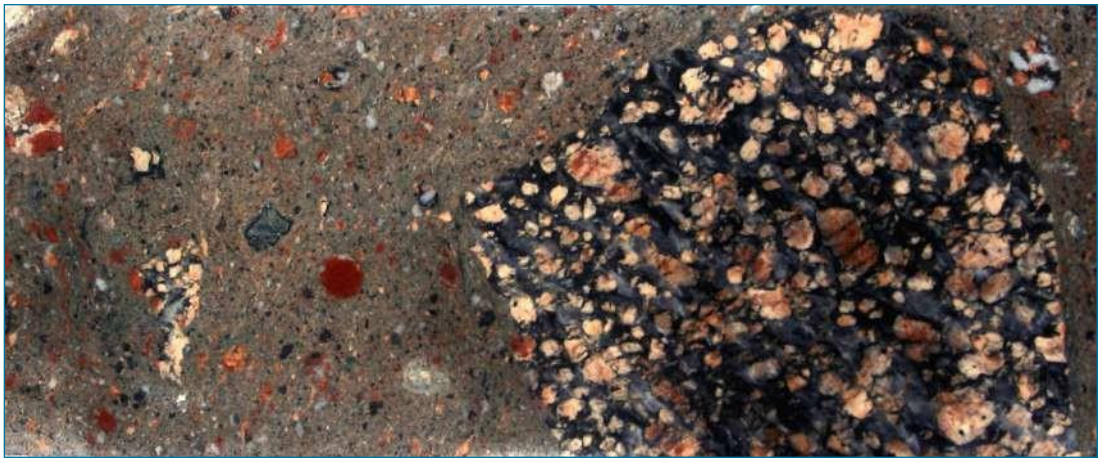


Fig. 5. Suevites of Ilyinets structure, the polished core of 9D drillhole (depth 121.2 m). Core diameter is 76 mm (Prykhodko et al., 2013).

Fig. 6. The elongated “bomb” from the thickness of the Ilyinets crater. Longitudinal cutting, 6×13 cm bomb. Sample from the Gurova E.P. collection.

Shock-melt rocks are solid glassy and massive, mostly black. The colour changes to brown as a result of weathering. Due to high glass content (up to 90%), they have an aphanitic texture. Previously, they were described as andesidacites and felsite porphyry. These rocks are developed in three locations of the Ilyinets structure.The central one is on the slopes of the central elevation, close to the contact with the brecciated target granites. The eastern locations are among the suevites of the eastern depression filled with mudstone. The third is the southern one. The cross-sections of the central locations show that the shock-melt rocks lenses have a steep fall. In the southern one, they form a subhorizontally-oriented oval-shaped formation body, up to 1.5x1.1×0.035 km. The contacts of shock-melt rocks with surrounding rocks are gradual and dim. The shock metamorphism leads to changes in the mineral composition of rocks and their textural and structural features. This process also causes the appearance of planar (thin parallel) fissures similar to cleavage in the minerals (Gurov, 2002). The planar fissures have been found in quartz, feldspars, biotites, amphiboles of allogenic breccias (Valter et al., 1982; Gurov et al, 1998). Destruction cones, diaplectic and molten glass, spotty anisotropization of minerals, bands of biotite, geochemical anomaly of iridium, etc. are also observed (Valter , 2008).

In the granitoid and gneiss fragments of the authigenic breccia upper horizon, the porphyroclastic structures appear, which are caused by the spread of intensively deformed large grains of quartz and feldspar in fringes composed of small mica aggregate or newly formed quartz. .

Valter A.A. (Valter et al., 1982) estimated the impulse pressure of feldspar-sanidine transformations at 40-50 GPa (400-500 kbar) and the temperature at 1500 ° C. The predominant orientation of the angles between the planar element poles and the optical quartz axis (omega factor) indicates a shock at a peak pressure of 16-20 GPa (Masaitis et al.,, *1980*).

The comparison of the average composition of impact and basement rocks shows that the content of impact and molten rocks is characterized by a decrease in the content of silica, ferrous iron, magnesium, calcium and sodium, and increase of oxide iron and potassium (Prykhodko et al., 2013). The most significant is the difference in the content of alkalis and iron. The degree of iron oxidation increases from the basement to shock-melt rocks, in other words from the bottom up. In the shock-melt rocks, the content of disthene, corundum, and graphite, characteristic of high-dimensional and restorative conditions of mineral formation, increases in comparison with granites and suevites.

The ore hydrothermal minerals (chalcopyrite, pyrite, galena, sphalerite, molybdenite), as well as non-metallic ones (barite and fluorite), are distributed regularly in all varieties of both coptogenic and sedimentary complexes. The next hydrothermal processes are likely to occur after the completion of formation of both complexes and are associated with the Cimmerian tectonic-magmatic activation of the southwestern margin of the Eastern European Platform.

Metal and silicate spherules were found in the rocks of the Ilyinets structure. These particles, even in shape and size, have a different composition, type of inclusions and impurity elements. Among the spherules were found: those which are strongly magnetic, hollow inside. They can consist of magnetite, magnetite-iocyte, iocyte and magnesioferrite-iocyte; magnetic with a spherical core of native iron and a shell composed of iocyte or glass saturated with skeletal crystals of manganese ulvospinel; silicate glass containing inclusions of skeletal crystals of magnetite, alumochromite, spinel, iocyte. The cogenite micron-size inclusions are present in native iron.

The isotopic age of the Ilyinets structure molten rocks, which underlies allogeneic breccias, is 445 million years (corresponding to the Ordovician) according to the 40Ar /39Ar method (Pesonen et al., 2004) and the results of paleomagnetic studies performed by scientists at the University of Helsinki. This age is considered to be the most reliable. Earlier definitions (1972) of the K-Ar method in the IGFM (now IGMR NAS of Ukraine) indicate the age of the Ilyinets meteorite crater rocks to be about 400 million years (Radzivill et al., 1986).

Geological and touristic route to the Ilyinets meteorite crater. Here we present the developed route of the geological excursion within Vinnytsia region, the top object of which is the geological natural monument “Ilyinets Crater”.

The geological excursion is designed for one day and consists of 4 observation points. The last stop can be used as an extra.

1 – Kalnyk village. Flooded granite quarry

The quarry is located on the left bank of the River Sob on the eastern outskirts of Kalnyk village and about 20 km to the east of Ilyinets Crater (Fig. 7). The Paleoproterozoic granitoids of the Gaisyn complex, typical representatives of the target species, are revealed there.

In the 1960s granite was mined in the quarry. Now the quarry is no longer worked and is flooded (Fig. 8 A). Two ledges of shallow excavation in its southeastern part remain available for study (Fig. 8B),

Fig. 7. Kalnyk granite quarry in Google satellite image. The arrows indicate the observation points and their number.

where probably after the completion of the industrial production granites were mined in a small amount for local needs.

Accessory minerals are apatite, zircon; secondary. Secondary minerals are actinolite, chlorite, carbonate, graphite.

A B

Fig. 8. General view of a granite quarry near Kalnyk village. A - view from item 1-2 on the flooded main part, B - excavation.

In the excavation walls, a typical granite-like association outcrops: biotite-amphibole diorites and granodiorites, amphibole-biotite tonalites and plagiogranites, biotite two-feldspar and aplite-pegmatite and aplite-pegmatite granites.

At the entrance to the excavation in a small ledge (point 1-1, N49°02’15’80 «E29°24’39’50»), grey biotite-amphibole, biotite diorites, tonalites, plagiogranites are massive, medium-grained, replaced by two-feldspar granites. These granites are pinkish-grey and often with spotted structure due to the microcline inclusions. The change occurs in two ways. The first (the most common) is a relatively uniform shadow replacement. The second one is the unequal enrichment of microcline and quartz with the formation of migmatitic rocks, in which the melanosome is represented by poorly modified plagio- and leukosoma - two-feldspar granitoids. Mineral composition of granitoids: plagioclase-oligoclase, quartz, biotite, amphibole, microcline of replacement.

There are several stages of retrograde metamorphism granite transformation under P-T conditions from amphibolite to green-shale facies. In the early stages, there was the rock crushing, which was accompanied by recrystallization of the mineral grains’ contact zones during interclass sliding under conditions of compression and filling of biotite with apatite mineralization of cracks under stretching conditions. Quartz was deformed, plastic in compression areas and granularized in shear areas, decomposing into sub-basins most often with a serrated (suture) contact surface. The wavy extinction attests to the dynamic nature of the restoration of quartz subgranular.

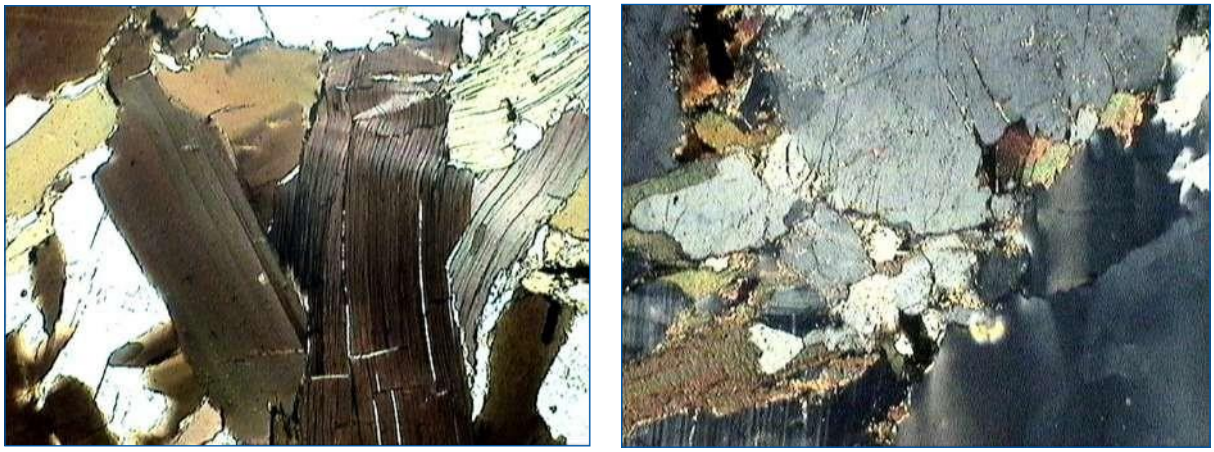
In the next stages of tectonic transformation, the rock-forming minerals - plagioclase, quartz, biotite, amphibole, are deformed intensively (Fig. 9). A network of cracks, kink bands, grain breaks, and recrystallization of grain contacts are formed. Carbon dioxide solutions actively penetrated the cracks, which led

to the crystallization of calcite and graphite, as well as the replacement of green amphibole by chlorite and actinolite.

Some grains of clinopyroxene are noted in some places. More intense sign of graphitization and carbonation also occurs sometimes. The graphitization reveals in cracks in virtually all grains of rock-forming minerals and is accompanied by carbonation. Graphite, calcite, and chlorite form crusts around the accessory minerals, or pseudomorphically replace them.

Two-feldspar biotite granites (Fig. 9) with coarse-grained and porphyric-like structure contain tectonized inclusions of quartz-feldspar composition, deformation bands and subsequent decay of the grains into sub-grains under dynamic restoration. Further transformation of granites occurs with the appearance of crack formation, quartz recrystallization, deformation and rupture of biotite plates, local redistribution of microcline, carbonate cracking and a small amount of graphite.

On the opposite side of the excavation wall (point 1-2, N49 ° 02’18,10 «E29 ° 24’44,00») massive, porphyritic, sometimes unclear striped, grey-pink and pink biotite, amphibole-biotite medium-grained granite and granodiorites outcrop (Fig. 10 A). Porphyropic inclusions of individual grains microcline or its ag-



A B

Fig. 9. The character of micro-deformations in biotite plagiogranites (point 1-1).

fringed by linear-elongated biotite aggregates, thereby making their structures look lepidogranoblastic. Feldspars are cataclastic, internally cracked, characterized by deformation of the polysynthetic twin of plagioclase and the formation of a spotty microcline lattice and its deformation. Biotite occurs on cracks and deformation bands in the feldspars. On the contact of microcline with plagioclase myrmekite occurs. Quartz is deformed plastically with the formation of gregates reach 4-5 cm. Among the granites, there are single inclusions of dark grey diorite and crystalline schist, which look like melted ovals up to 25×15 cm in size (Fig. 10 B). These rocks form the main background of this part of the quarry.

Here and further in the photo the size of the long side of the shot is 1.43 mm; never crisscrossed.

Amphibole-biotite granites and granodiorites consist of plagioclase, microcline, quartz, biotite,

A B

Fig. 10. Granites and granodiorite (biotite and amphibole-biotite, point 1-2).

secondary chlorite, graphite, calcite, accessory apatite, and zircon. Hypidiomorphic-granular texture with maximal plagioclase idiomorphism relative to potassium feldspar and quartz is featured. There are elements of rock-forming minerals deformation, intergranular recrystallization in the form of micromyrmekite aggregates at the boundaries of plagioclase and K-feldspar grains. The rock-forming mineral grains are deformed, characterized by wavy attenuation and the presence of bands of deformation, bending of twin growths of feldspars and biotite plates, granulation of quartz grains. There is a system of parallel healed cracks traced by microinclusions similar to planar fractures (Fig. 11).

In the east wall of the excavation (point 1-3, N49 ° 02’16,10 «E29 ° 24’43,10»), pink-brown two-feldspar granitoids are revealed. In this rock there

Fig. 11. Signs of planar fracture in feldspars and quartz (point 1-2).

are different morphologies of grey relic bodies up to 1.5 meters in size, which are composed of altered and tectonized amphibole-biotite crystalline gneisses (Fig. 12). The crystalline schist is grey, dark grey with a greenish tinge, fine-grained. On the edge of the relic, a biotite rim is often observed. According to the geologists of the Pravoberezhna GRE, relics (up to 2-3 m) of carbonate-silicate rocks (from calciferous to scapolite-diopside rock) were also observed in the of the flooded part of the quarry.

Biotite granites have a porphyritic texture, the bulk being medium-grained, hypidiomorphic-granular with plagioclase idiomorphism to quartz and the development of a myrmekite at the microcline and plagioclase grains contacts of microcline and plagioclase (Fig. 13). The quartz, as well as feldspars, is characterized by wavy attenuation and decays into sub-grains with a specific contact surface. The mineral composition of the rock (%): plagioclase –35, microcline – 35, quartz –28, biotite, chlorite, graphite – 2, calcite, apatite, zircon.

The biotite crystalline schist and plagiogneiss are modified to varying degrees. The rock’s texture is lepidoblastic, with porphyroblastic elements. Mineral composition (%) is: porphyroclast mesoperthitic - 24; main mass: plagioclase - 34, quartz - 15, biotite - 25, chlorite, calcite, graphite - 1, apatite, zircon.

As was shown, the rocks at the micro level show intense multistage tectonic transformations, some of

Fig. 12. Pink-brown two-feldspar granitoids with relict of amphibole-biotite gneisses and crystalline schist (point 1-3).

Fig. 13. Biotite granites in thin-section (point 1-3).

which may be related to the impact events that led to the formation of the Ilyinets Crater. Particularly important in this regard are the above-mentioned elements of planar structures, which in the Kalnyk quarry require further study.

2 – Luhova village, Geological monument of nature «Ilyinets Crater»

We can get acquainted with the peculiarities of the geological structure of the southern part of the Ilyinets meteorite crater in quarries and natural outcrops, study a variety of the impactites' structural and textural types.

Near **Luhova village** on the left bank of the Sobok River in quarries shock-metamorphosed rocks are exposed (Fig. 14, 15). Geographic coordinates of main quarry N49 ° 06'00,04 «E29 °06'24,66».

It should be noted the impactites were mined as rubble stone for local needs up to the 1960s. Now the outcrops of the Ilyinets structure rocks are a geological monument of nature and protected by law.

It is believed that a massive meteorite under the pressure of 5000 - 8000 atmospheres and at temperatures above 3000°C crashed into the Earth's crust to a depth of 800 m and exploded. In this case, the target rocks partially melted, split apart, sintered and formed a new complex of rocks - impactites.

The different types of impact rocks are formed at various stages of the impact process and in diverse parts of the impact structure. The peculiarities of the composition and structure of such rocks depend on their original location and distance from the center of impact, the composition and structure of the tar-

Fig. 14. General view of the impactites' quarry, which can be a part of the Geosite

Fig. 15. Spherical impactites' body in the quarry near Luhova village

get, the type of material movement in the cratering process, and the final position of rocks in the impact structure (Gurov, *2002*).

Allogenic breccias and tufts (Fig. 16A), including "bombs", appear on the surface of the workings and quarries. The rocks underwent hypergenic transformations, which are confirmed by the presence of manganese, ferruginous and clay minerals, zones of silicification and mylonitization (Fig. 16B).

The meteorite crater circular bar was destroyed by further exogenous and endogenous processes and is not expressed in modern relief.

3 – Luhova village, place of millstone production

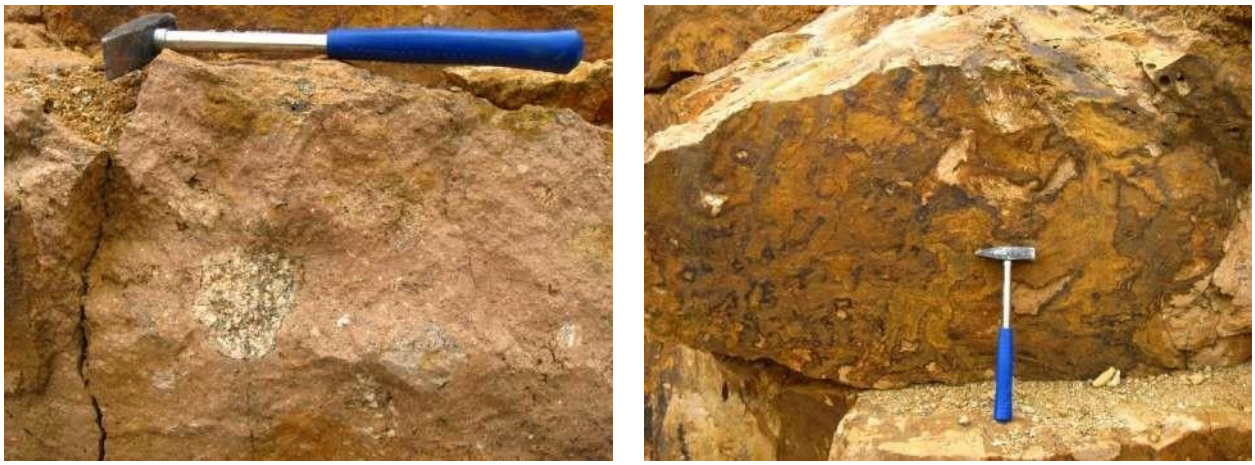
A site with traces of Chernyakhiv culture and signs of stone millstone production (Fig. 17) was found in the Ilyinets meteorite crater (Khavliuk, 1980; Klimovskii and Gurov, 2011). The researchers found marks of picks in ancient workings, numerous finds of millstones and defect millstones. Also, an almost six-meter layer of production waste from this activity was left. So there is no doubt about the functional purpose of the open object. The large-scale mining here was begun in the III BC by tribes of Chernyakhiv culture. Probably, with a slight interruption, it lasted until the pre-Rus time. The locals mined impactites and granitoids for making millstones - paired stone circles used in mills for grinding grain into flour (Fig. 18). The opening of the Ilyinets quarry was important for studying the history of production and economy of the ancient settlements of the region.

4 – Ivanky village, Geological monument of nature «Ilyinets Crater»

Here we can find out about the geological structure features of the boundary part of the crater (N49° 06'04,72" E29° 04'41,78") in the quarry near the village Ivanky on the banks of the River Sobok (Fig. 19). Also, we can study impactites, their mineralogical, structural and textural features and hypergene changes.

The quarry revealed shock-metamorphosed rocks, which belong to the lower complex of the Ilyinets structure impactites. They are represented by allogenic breccia and suevites (Fig. 20).

Over millions of years, the crater was destroyed



A B

Fig. 16. Impactites and its hypergene alterations

Fig. 17. Stone mining site of the 3rd century AD (the Chernyakhiv culture).

Fig. 18. Ancient millstones, which are made of suevites

Fig. 19. General view of the quarry near Ivanky village

by tectonic and denudation processes. These processes continue at the present stage. Therefore, fragments of a meteorite crater can only be distinguished in quarries and, occasionally, in outcrops. Everywhere, the suevites have undergone significant secondary alterations and have acquired various shades of yellow, brownish, and brown.

Conclusions. It should be noted that in contrast to other impact structures of Ukraine, which are covered with a thick layer of rocks, the Ilyinets meteorite structure is opened by quarries of the Chernyakhiv culture stone mining. Such works revealed the crater's southern edge, so we can observe the internal compounds of cosmogenic origin structure. This allows us to see not only the geological history of this point on the Ukrainian Shield but also to touch the history of the region.

The geological route was developed to present

Fig. 20. Impactite outcrops in the quarry walls near Ivanky village. The rocks are varying in degrees of hypergene alteration

geological objects in chronological order. The geological excursion will allow visitors to learn about meteorite craters in general; to feel the threats posed to our planet by cosmic bodies; to touch the secrets of the Ilyinets Crater, which will allow us to learn the geological history of our planet and the universe. At the end of the route we will look at the millennial prints of the Chernyakhiv culture, traces of which were found on the edge of the Ilyinets structure.

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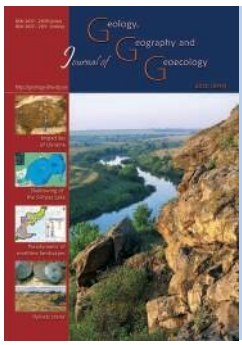

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Shallowing of the Svityaz Lake in the context of regional climate change

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Abstract. The paper analyzes the dynamics of the main climatic indicators in order to reveal the role of regional and local factors in the current changes in the water content of the Svitiaz Lake (NW Ukraine). The current state of study of the water balance of the lake and the factors that form it are estimated. The main trends for changes in the levels and regime of surface water, groundwater and artesian water in the territory of the Shatsk National Nature Park are identified. Quantitative data characterizing long-term and modern changes in water levels in the lake are presented. Shallowing of 2019 is characterized (the lowest water level over the last 50 years, reduction of the water mirror area by 8%). Based on statistical mathematical and cartographic analysis of climatic data provided by 17 meteorological stations in the region the dynamics of average annual, monthly and seasonal precipitation, evaporation and their spatial distribution were estimated. A significant increase in evaporation during the warm period of the year over the last decades (2000-2018) has been revealed. Changes in the amount and mode of precipitation over 2 long-term periods are estimated. The peculiarities of the dynamics of the main meteorological indicators in 2019 (average monthly and average annual air temperatures, relative humidity, precipitation amounts) were separately analyzed. Values of humidity coefficients and hydrothermal coefficients were calculated. The parts of the region with the lowest values of these indicators, including the catchment area of Lake Svityaz, are outlined and visualized on the map. The significant role of evaporation growth was confirmed given the consistent increase in air temperatures over the last 20 years. Given the Svityaz station data it is also calculated the correlation coefficients of water levels in the lake with the same indicators for the period since 1970. During the period of 2000-2018, a significant increase in the dependence of water levels on the hydrothermal coefficient of Selyaninov was established, which may indicate a decrease in the ecological stability of the lake and its increasing vulnerability to climate change.

Key words: Svitiaz Lake, shallowing, water level, precipitation, evaporation, hydrothermal coefficient.

Обміління озера Світязь під впливом регіональних кліматичних змін

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Анотація. У роботі проведено аналіз динаміки основних кліматичних показників для виявлення ролі регіональних та локальних чинників у сучасних змінах водності озера Світязь. Оцінено сучасний стан вивченості водного балансу озера та чинників, що його формують. Проаналізовано основні визначені на сьогодні тенденції зміни рівнів та режиму поверхневих, підземних і ґрунтових вод на території Шацького природного національного парку. Наведено кількісні дані, що характеризують багаторічні та сучасні зміни рівнів води в озері. Охарактеризовано аномальне обміління 2019 р., проявами якого були мінімальний рівень води за останні 50 років та скорочення площі водного дзеркала на 8%. На основі математико-статистичного та картографічного аналізу кліматичних даних по 17 метеорологічних станціях регіону Західного Полісся проведено оцінку динаміки середньої річної, місячної та сезонної (теплий і холодний періоди року) кількості опадів, випаровуваності та їх просторового розподілу. Виявлено значне зростання випаровуваності у теплий період року протягом останніх десятиліть (2000–2018 рр.). Оцінено зміни кількості та режиму випадіння опадів за 2 багаторічні періоди. Проведено аналіз особливостей динаміки основних метеорологічних показників у 2019 р. (середні місячні та середні річні температура повітря, відносна вологість повітря, кількість опадів). Розраховано значення коефіцієнтів зволоження, що відображає співвідношення між середньою річною кількістю опадів та середньою річною випаровуваністю, а також гідротермічного коефіцієнта Селянинова. Визначено та візуалізовано на картах частини регіону із найменшими значеннями цих показників, які охоплюють в тому числі і водозбір озера Світязь. Підтверджено значну роль зростання випаровуваності на фоні поступового збільшення температур повітря протягом останніх 20 років. По станції Світязь також обчислено коефіцієнти кореляції рівнів води в озері із цими показниками,

починаючи із 1970 р. За проаналізований період у другій половині XXст. виявлено відсутність сильних кореляційних залежностей рівнів води від середньорічної кількості опадів, випаровуваності та коефіцієнта зволоження, але з певним зростанням коефіцієнтів кореляції у багаторічному ході. За період 2000-2018рр встановлено суттєве зростання залежності рівнів води від гідротермічного коефіцієнта Селянинова, що може свідчити про зменшення екологічної стійкості озера та все більшу його вразливість до кліматичних змін.

Ключові слова: озеро Світязь, обміління, рівень води, кількість опадів, випаровуваність, гідротермічний коефіцієнт

Introduction. The Lake Svityaz, the deepest and one of the largest lakes in Ukraine, is the most famous object of the Shatsk National Natural Park (SNNP), and its lake area is one of the largest recreational systems of the region. The uniqueness and particular value of the park ecosystems has been also proved by its inclusion in the transboundary international biological reserve "Zachidne Polissya".

In recent years, we observed a decrease in average water levels in the lakes, and in 2019 the lowest water level of the Lake Svityaz since the beginning of observation in the park (Chronicle of Nature of Shatsk NNP, 2020) was recorded. Due to the peculiarities of the morphology of the lake basin (wide shallow part), these changes, being well seen by the naked eye, caused significant concerns of the public. Since July 2019 the issue of lake shallowing has been raised at different levels of authorities, is widely covered in the media. The attention to the issue is certified by 4 petitions registered on the website of the President of Ukraine, a few extraordinary meetings of the Committee on Environmental Policy and Nature Management of the Parliament of Ukraine (November 12, 2019, February 13, 2020), establishing of working groups on the issues of Shatsk lake shallowing in the regional and all-Ukrainian level.

Scientific discussions of the problems took place, in particular, at the meeting of the Coordinating Committee of Shatsk Interdepartmental Scientific Research Ecological Laboratory (Shatsk Experimental Base of the Institute of Physics and Mechanics (IPM) named after Karpenko G.V. of the National Academy of Sciences of Ukraine, October 11, 2019), at the Interdepartmental Scientific and Practical workshop "Hydroecological situation of lakes in Volyn region: a problem or a catastrophe" (Lutsk NTU, 18.10.2019), at the meetings of working groups dealing with the problems of shallowing of the Shatsk Lakes (17.12.2019, 13.01.2020, 13.03.2020), meetings of the Regional Office of Water Resources in the Volyn region, the Pripyat Basin Councils, the Western Bug and San Councils, etc. The authors of this research were involved and attended almost all of the above-mentioned meetings, which allow them to assess problem coverage and to make stand out a number of insufficiently highlighted issues.

Review of previous research. Detailed water balance studies in the region began in the 1960s in connection with the planning and conducting of the large-scale drainage reclamation. Significant researches were conducted by the Institute of Hydraulic Engineering and Land Reclamation (nowadays, the Institute of Water Problems and Land Reclamation) of the National Academy of Agrarian Sciences of Ukraine. In particular, the main income and expenditure components of the water balance, water exchange intensity, indicators of ecological sustainability of lakes, etc. have been evaluated (Romashchenko, Bakhmachuk, 2004; Yatsyuk et al., 2019]. Since the early 1990s and until now, high attention is paid to assessment of possible impact on water regime of Svityaz of the Khotyslav quarry in Belarus (Diatel, 2019; Yatsyuk et al. 2019; Zuzuk, Melnychuk, Zaleski, 2012).

The role of pressure waters, features of their occurrence, dynamics of levels have been studied in the works of Rivne geological expedition, Kovel hydrogeological and reclamation party. Generalized data are provided in the works of I.I. Zaleski (Zaleski, 2014a, 2014b).

Since 1985, the park staff has been conducting constant observations of surface water levels, the data of which, along with meteorological indicators, are being analyzed in the annual chronicles of nature. A continuous series of observations has been formed with regards to the Lake Svityaz. As for the other lakes, as well as groundwater and underground water levels in the region, monitoring data are available only for certain periods.

Since 2010, the system of Integrated Environmental Monitoring (IEM), organized by the IPM named after Karpenko G.V. of the National Academy of Sciences of Ukraine (Panasyuk, Yurchuk, Koshovyy, Muravskyy et al., 2012). The system integrates networks of test sites, soil sections, wells, etc., the data of which are combined with the analysis of remote sensing data. The results are entered in put into the Geo-Information Atlas of the Shatsky Biosphere Reserve (Information-analytical system…, 2020).

Climatic studies of this area have been presented in many researches, starting with the monographs "Nature of Volyn region" (1975), "Climate of Shatsk National Park" (1995) and continuing with modern both special (Alokhina, Ivantyshyn, Korus, Koshovyy, Popov, Rusyn, 2018; Diatel, Tsvietova, Saidak, 2018; Tarasyuk F., Tarasyuk N., 2017; Tarasyuk

N., Hanushchak, 2017) and general (Fesyuk, Puhach, Slashchuk et al., 2016; Ozero Svitiaz…, 2008) works that reflect various aspects of the region's climate and its changes.

In general, based on the analysis of publications dedicated to changes in the water content of the lakes of the SNNP over the last decade, the following can be distinguished:

- the territory undergoes significant changes in climatic indicators, in particular, there is an increase in average air temperatures, increased evaporation and changes in precipitation;

- the average levels of groundwater and underground water that supply the reservoirs of the park are decreasing, and their seasonal decline begins earlier (in recent years more often it takes place in April-May, in previous years – in June-July);

- significant increase in the amplitude of fluctuations in groundwater levels. In some periods, the decline of groundwater levels has peculiar features that do not correlate with changes in natural factors;

- increasing of waste when flow down (groundwater supply during their operation);

- there is a tendency to a certain synchronization of decreasing water levels of most lakes in the park, although previously they differed significantly.

Most of these trends began to appear in 2014-2015, but some had appeared even earlier (Yatsyuk et al., 2019). It is logical to assume that the significant shallowing of the Lake Svityaz in 2019 was not a sudden one-time phenomenon, while it is a consequence of the longer processes.

Among the main factors of shallowing are regional reflections of global climate changes, hydrogeological changes, progressive uncontrolled growth of municipal water consumption in recreational areas of SNNP, neglected reclamation and water control systems and structures, probable impact on groundwater of Khotyslav quarry, as well as newly created plantations of irrigated agricultural crops (blueberries) (Bondarchuk S., Bondarchuk L., 2016; Diatel, 2019; Yatsyuk et al., 2019).

The last factors are popular in the media, although as of today there are no objective evidence of such an impact. The results of the modelling show the probability of reducing the level of the lake Svityaz by 20 cm due to drainage during the operation of the Khotyslav quarry, subject to its depths of 45 m (Diatel, (2019). Nowadays, its depth is 12 m, no negative impact has been identified (Volyn Regional…, 2019). Regarding water consummation for blueberry cultivation, the maximum possible indicators are estimated at up to 0.6-1.1 million m^3 per season (according to Dr. Shevchuk and calculations made by the Institute of Water Problems and Land Reclamation (Yatsyuk et al., 2019). This is, for comparison, no more than 5-7% of the average annual evaporation indicator for the Lake Svityaz, however, these issues require further detailed study and monitoring.

To date, the most complete analysis of the main shallowing factors of the Shatsk Lakes is given in the Concept of the Shatsk Lake Conservation Program, presented in December 2019 by the scientists from the Institute of Water Problems and Land Reclamation (Yatsyuk et al., 2019).

Despite considerable attention paid to this problem, most of these works present the results of only local research within the SNNP. Therefore, **the purpose** of this research is to analyze and compare the dynamics of both local and regional climatic indicators to identify their impact on the change in water content of the Shatsk Lakes.

Materials and methods. The source materials for the study were archives of meteorological information posted on the resources of the World Data Centers and the web service of European Climate Assessment & Dataset (ECA & D). Analysis and calculations of climatic indicators were performed for 17 meteorological stations located in Volyn region and in adjacent regions – stations of Svityaz, Lutsk, Kovel, Lyubeshiv, Manevychi, Volodymyr-Volynsky (Volyn region), Rivne, Dubno, Sarny (Rivne region), Brody, Rava-Ruska, Kamianka-Buzka (Lviv region), Pinsk, Pruzhany (Republic of Belarus), Terespil, Wlodawa, Zamość (Republic of Poland) for the period of 1970-2019. For some periods with no actual observation data E-OBS modeling materials were used, the acceptability (reliability) of which, in particular, for the Volyn region, was confirmed by research (Shedemenko, Krakovska, Gnatiuk, 2012).

Dynamics of lake water levels of the Svityaz was analyzed for the period of 1970-2019 according to the observations carried out at the Svityaz meteorological station and at the Shatsk NNP.

Using statistical methods, the average values of precipitation, air temperature, relative humidity for each weather station for the months, warm and cold periods of the year, for the year and for the entire study period have been calculated.

On the basis of empirical calculation methods evaporation, humidification coefficient and hydrothermal coefficient have been determined.

The calculation of evaporation was carried out according to the well-known method of N.M. Ivanov (which is often called V. Romanenko's formula in Western literature) (Xu, Singh, 2001), which takes into account the average monthly indicators of temperature and relative air humidity. The coefficient of

humidification of the territory was defined as the ratio of precipitation to evaporation for the respective monthly or annual periods. As it is known, evaporation means the maximum possible evaporation under these temperature conditions, not limited to moisture reserves (mm).

Among the alternative methods for calculating evaporation from the surface of the water mirror, the methods of L. Turc (1954) and Thornthwaite C. W (Xu, Singh, 2001) have been also used to verify the obtained results.

The hydrothermal coefficient of Selyanynov, which is defined as the ratio of precipitation for the period with average daily air temperatures above 10 ° C (period of active vegetation) to the sum of air temperatures for the same period divided by 10, has also been calculated.

The spatial distribution of the calculated indicators is represented by GS Surfer cartographic means using methods of interpolation of local polynomials and radial basis function. To estimate the change in the surface of the lake, the methods of automatic classification of Sentinel-2 satellite images according to the NDWI indicator in EOS LandViewer were used.

Results and discussion. The analysis of archival data on the water levels of Lake Svityaz for the period of 1970-2019 showed that they have a pronounced seasonal dynamic with low winter, maximum spring and minimum summer-autumn indicators. Fig. 1 presents typical intra-annual fluctuations of lake water levels in high-water and low-water years.

At the same time, the amplitude of the levels is small, for a long period it was less than 0.9 m. The lowest level was recorded in 1972-162.97 m (associated with the previously conducted drainage reclamation), the highest - 163.79 m in 1981. During the existence of the park, the difference between the maximal and minimal levels was even smaller (up to 40 cm was average annual, up to 60 cm was average monthly indicator). However, in 2019 this amplitude has significantly increased. Starting from July, water levels fell below the previous minimums of 1994 and 2015, and in autumn (level 162.92 m) – less than the long-term minimum of 1972. The examination in October 2019 revealed a deviation of the water body from the shoreline from 3-5 m to 40-90 m in different areas (Chronicle of Nature of Shatsk NNP, 2020).

To estimate the total area of water surface reduction, a number of space images were analyzed using automatic classification in several combinations of multispectral image channels (in LandViewer service by EOS Data Analytics). The Normalized difference water index (NDWI) is most often used to estimate changes in the area of water bodies, which identifies the water surface well by estimating the ratio of reflected radiation in the near and short-wave infrared ranges (Xu, 2006). Having automatically classified images from the Sentinel-2 satellite, data on the ratio of areas with different values of the NDWI index for individual dates from autumn 2018 to autumn 2019 were obtained (Fig. 2).

Therefore, for example, it was found that in April 2019 (level 163.29 m) the area under water was 74 hectares larger than in November 2018 (level of 163.17 m), but in the summer months it began to decline rapidly, and at a minimal level (162.92 m in autumn 2019) it was already 155 ha smaller than the spring indicators. The amplitude of the analyzed values for the studied period was about 251 ha.

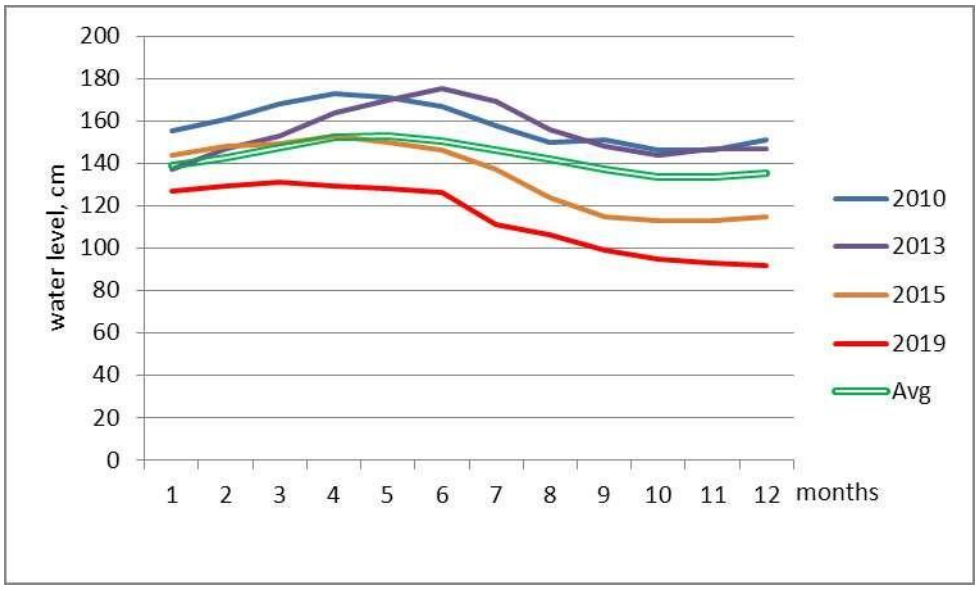

Fig. 1. Intra-annual fluctuations of lake water levels in high-water (2010, 2013) and low-water (2015, 2019) years.

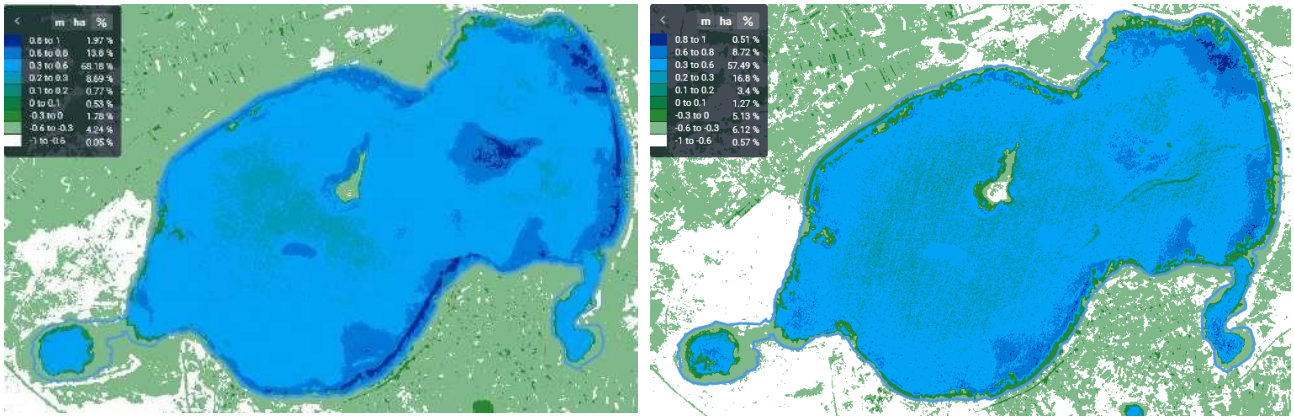

Fig. 2. Results of comparison of pictures Sentinel-2 dated 02.04.2019 (left) and dated 01.11.2019 (right) by means of automatic classification according to NDWI using EOS LandViewer.

Further we will consider the main climatic indicators that can significantly affect the reduction of water content of the lake, in the temporal and regional context.

Precipitation. Analysis of precipitation dynamics in the XXI century according to 17 meteorological stations in the region showed that, despite some low-water years, the average annual precipitation increased by 20-45 mm (Fig. 3), which is 3-10% of the climatic norm.

However, the average monthly precipitation indicators are characterized by a very high variability. An increase in precipitation is evidenced in January, March, April and May. In other months of the year there is mainly a decrease in the average monthly precipitation (the largest decrease was observed in February, June, August).

At the same time, the annual number of days with precipitation decreased by 25-30%. For example, for Svityaz meteorological station at the climatic norm of 164 days with precipitation per year, the average value for the period 2000-2018 is 121 days. The dynamics of precipitation during the year also changed: the distribution of rainy days became more uniform over the seasons. Thus, on Svityaz weather station the ratio of days with precipitations of the cold and warm period makes 54/67, and average value in the region is 60/82.

Against a slight increase in the average annual precipitation, compared to the climatic norm, some years become arid (for example, 2015, 2019). In 2019, only 4 of the 17 weather stations had a positive deviation in precipitation compared to the climatic norm. At other stations, a decrease in the annual precipitation was recorded, the most significant was for Lyubeshiv, Terespol, Zamość, Svityaz and Lutsk (Fig. 4).

According to several regional climate models indicators, such situation should not become typical, most forecasts do not predict (Krakovska, Palamarchuk, Gnatiuk, Shpytal, Shedemenko, 2017) a significant reduction in precipitation in the region. However, even if the annual precipitation

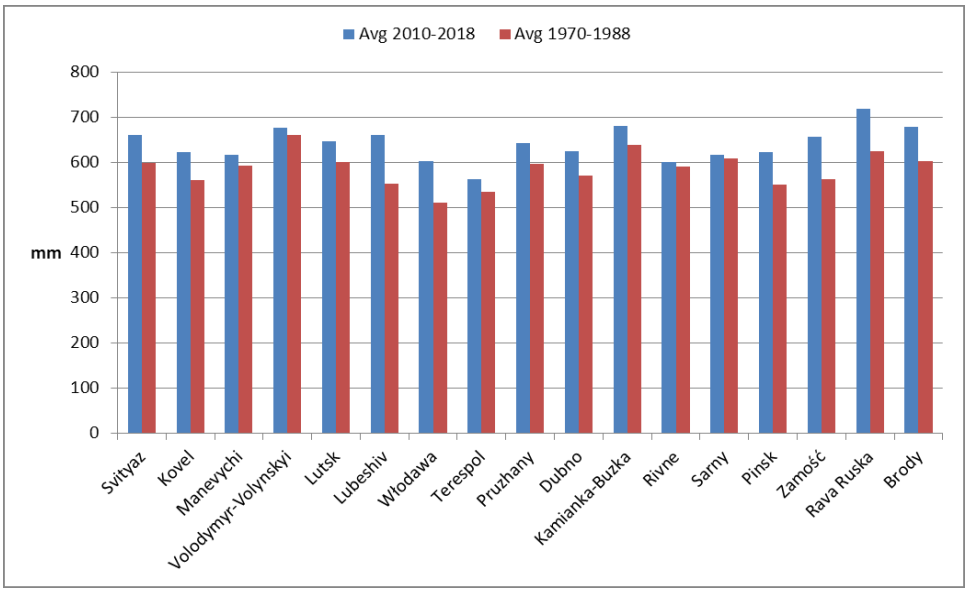

Fig. 3. Comparative diagram of the average annual precipitation at 17 weather stations in the region

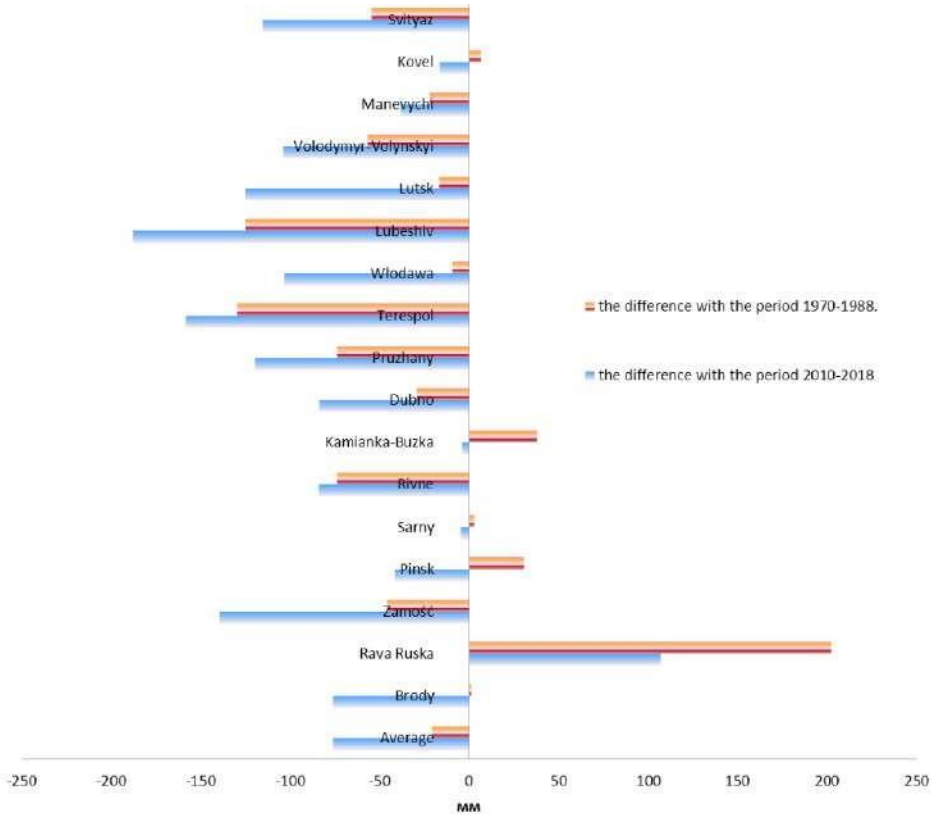

Fig. 4. Deviation of precipitation in 2019 at meteorological stations in the region compared to previous periods

is maintained at the level of the previous period or slightly increased, evaporation becomes a significant factor in reducing water content.

To compare the dynamics of *evaporation* from the surface of the water mirror of the Lake Svityaz during the period of global climate change, two periods were analyzed: 1970-1988 and 2000-2018. The archival data of the Svityaz meteorological station, which is located almost on the lake shore, were used. The analysis of meteorological indicators of 2019 is carried out separately. The choice of such time segments is caused both by existence of continuous series of data for this time, and by representativeness of the corresponding periods.

The table 1 presents a summary of the calculation of average monthly and annual values of air temperature, relative humidity, precipitation, evaporation and humidity for the two studied time periods.

According to the statistical analysis, over the last 19 years a significant increase in evaporation has been observed at the Svityaz meteorological station: both calculation methods have shown the actual average annual value of evaporation in the range of 635-650.6 mm / year. At the same time, the average annual precipitation for the same period was 574.6 mm. The growth of the average annual precipitation occurred within 6.5%, while the growth of the average annual evaporation rate ranged from 15% (calculated according to the method of L. Turc) to 25% (calculated according to the method of N. Ivanov). It seems to us the calculation according to the method of N. Ivanov is more accurate, since it takes into account a wider range of climatic parameters and has repeatedly tested in temperate-continental climate (Xu, Singh, 2001). The Fig.5 clearly shows the current trends in recent decades, the growth of evaporation rate and decrease in humidity coefficient, especially in summer, compared to the period of 1970-1988.

Analysis of the dynamics of evaporation by months of the year shows that a particularly progressive growth of this indicator is observed in the warm period. This obviously correlates with the fact that evaporation is directly proportional to the temperature of air and water. If in November-March the evaporation for the period of 1970-1988 and of 2000-2018 is almost the same, then in April-October the average monthly increase in evaporation is from 20 to 50% in the period of 2000-2018 (compared to the period 1970-1988).

Comparison of average monthly values at the Svityaz meteorological station indicates that the average monthly evaporation for the period 2000-2018 consistently exceeds the average monthly precipitation by 20-30% from April to September, and in August the indicator can reach 50%.

Table 1. Average monthly values of climatic indicators in the Svityaz meteorological station (comparison of 2 periods, 1970-1988 and 2000-2018)

Month of the year	Air temperature, T, ^{0}C		Relevant Humidity of air, F, %		Precipitation amount, R, мм		Evaporation, W, mm (acc. to L. Turc)		Evaporation,W, mm (acc. to N.M. Ivanov)		Humidification coefficient	
	1970-1988	2000-2018	1970-1988	2000-2018	1970-1988	2000-2018	1970-1988	2000-2018	1970-1988	2000-2018	1970-1988	2000-2018
January	-3.7	-2.7	82	83	32.5	34.2	15.1	19.3	14.7	15.2	2.21	2.25
February	-3.6	-2.1	81	80	24.5	34.7	15.3	20.6	15.7	18.9	1.56	1.84
March	1.8	2.4	79	76	32.2	35.5	26.7	30.1	27.1	32.4	1.19	1.09
April	6.2	9.5	74	69	30.2	38.8	36.0	45.2	45.6	66.4	0.66	0.58
May	14.5	14.8	79	70	51.3	64.1	65.9	69.3	58.9	85.5	0.87	0.75
June	16.8	17.7	77	71	74.9	75.6	77.7	85.0	72.3	95.2	1.04	0.79
July	17.9	20.3	79	72	83.9	82.6	84.2	102.1	69.6	103.4	1.2	0.80
August	17.4	19.3	78	72	54.0	47.9	80.1	95.2	71.2	98.9	0.76	0.48
September	13.3	13.9	81	78	51.7	45.7	60.5	65.1	50.2	59.9	1.03	0.76
October	7.6	8.4	84	81	35.5	40.3	41.7	45.0	30.6	38.2	1.16	1.05
November	3.1	4.2	85	86	31.3	35.6	24.6	34.1	21.3	21.5	1.47	1.66
December	-1.8	-0.5	85	86	36.4	39.6	18.2	23.9	14.5	15.1	2.51	2.62
Average per year (or total)	7.4	8.8	80.3	77.0	538.4	574.6	546.0	635.0	491.7	650.6	1.09	0.88

We will separately analyze the meteorological indicators of 2019 at the Svityaz meteorological station, because that year the area of the lake's water mirror has rapidly decreased. 2019 appeared quite arid, for 12 months the precipitation was 12% (-70 mm) less than the average value for the period 2000-2018, in warm period the deviation of the precipitation amount from the average is 15% (-65 mm). At the same time, there was further increase in average monthly air temperatures. As a result, for the first time during the period of instrumental observations, the average annual air temperature exceeded the mark of 10 ° C (+10,4 ° C). Accordingly, evaporation processes intensified: the deviation is positive for 9 months out of 12, for almost the entire warm period of the year (except May). The total increase in evaporation for 12 months of 2019 was 74.5 mm (+ 11.5%) compared to the average value for 2000-2018, while the increase in evaporation in the warm period of 2019 was 71.5 mm (+12 %), i.e. evaporation exceeded the average values for the last 20 years by 10-12%. Such an increase in the expenditure part of the water balance together

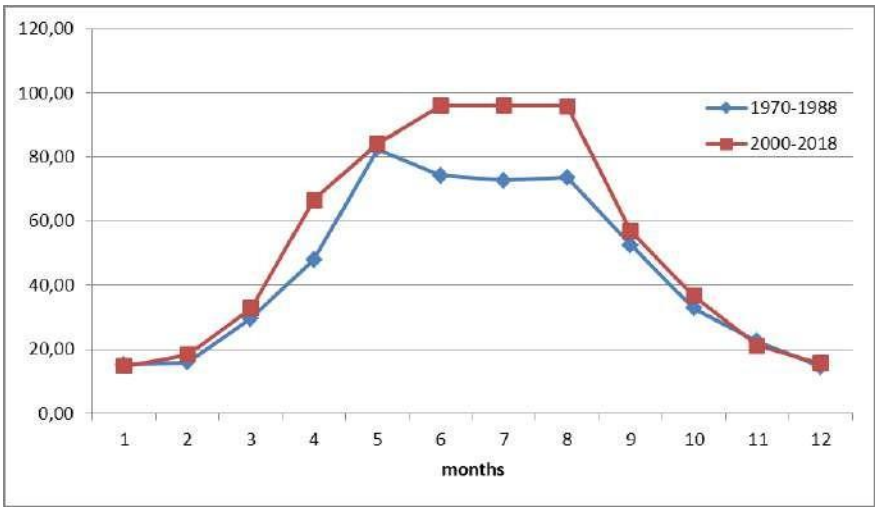

Fig. 5. Average monthly values of evaporation at the Svityaz meteorologicsl station for long-term periods

with a decrease in the amount of precipitation could give a total decrease in the water level of up to 21-30 cm. Abnormally high values were also recorded for groundwater evaporation – in some wells along with lateral runoff these values reached 740 mm (and 980 mm in the previous, 2018 year) (Yatsyuk et al., 2019), which also had a very negative impact on the water content of the lake.

We would like to emphasize, that according to the analysis of the temperature indicators for 17 meteorological stations in 2019, a similar increase in average temperatures was recorded throughout the region, but there are some differences in the integrated humidity indicators. According to the humidity coefficient, 8 from 17 stations in 2019 had values slightly higher than 1.0, and 9 stations – less than 1.0, which indicates a lack of humidity (in particular, Terespil 0.74, Lyubeshiv 0.85, Pruzhany and Wlodava 0.91, Lutsk, Volodymyr-Volynskyi, Svityaz – from 0.94 to 0.97). Similar distribution is attributed to the values of the hydrothermal coefficient HTC (Fig. 6).

As it can be seen, the lowest values of HTC (0.9-0.95) are typical for the Upper Pripyat lowland and the Shatsk lakes. HTC less than 1 are typical for the slightly arid climate.

Correlation analysis of water levels in Svityaz with separate series of long-term climatic data. The paper (Alokhina et al., 2018) indicated that the most significant correlation (-0.5) was found with the TSI (total solar radiation), which, apparently, indirectly affects most other meteorological indicators.

The pairwise correlation coefficients between the water level in the lake and such meteorological indicators as evaporation, precipitation, humidification coefficient, hydrothermal coefficient (HTC) were determined in our study. For the entire period from 1970 to 2018, the average values of correlation coefficients are small: between lake water levels and evaporation 0.21, between lake water levels and annual precipitation 0.18; between the water levels of the lake and the humidity coefficients 0.21-0.25. Nevertheless, if the calculation is carried out with an offset of 1 year (i.e. the water level of the current year is compared with the climatic indicator of the previous year), the correlation with precipitation and hydrothermal coefficient increases to 0.46-0.49.

However, significant changes in the correlation between the mentioned parameters have been revealed in the last 2 decades. Since 2000, the correlation between lake water levels and evaporation is -0.49, and the correlation with the hydrothermal coefficient is 0.66. Instead, during this period, in fact, the relationship with the humidity coefficient (according to N. Ivanov), remains unchanged and the correlation with the annual amount of precipitation decreases sharply (to less than 0.1 indicator, while in 1970-1988

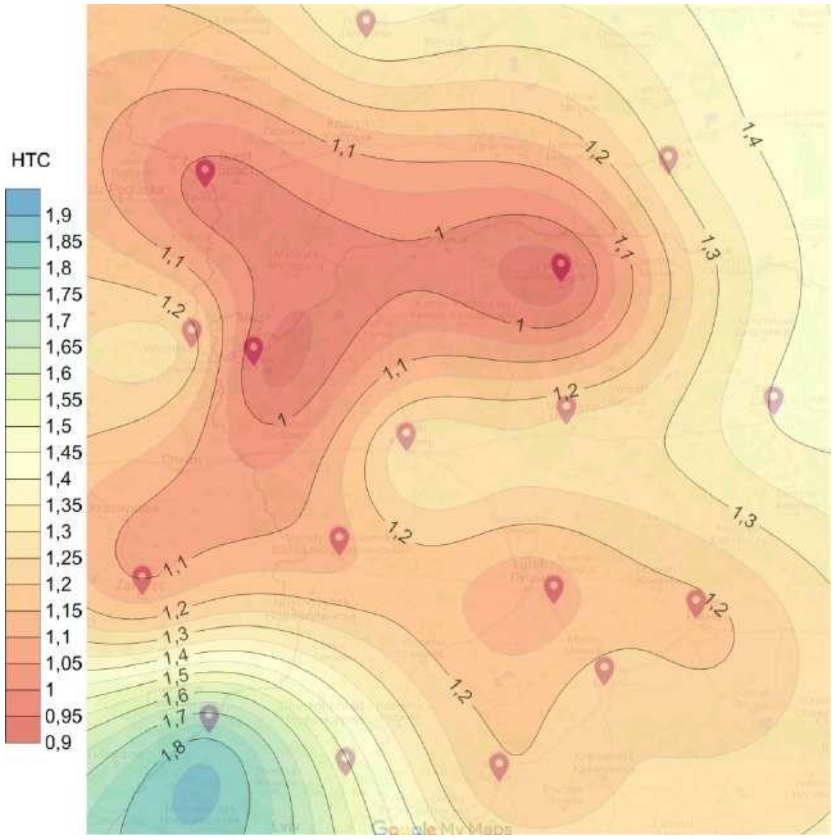

Fig. 6. Distribution of HTC (hydrothermal coefficient) in the region in 2019.

it was up to 0.5). Thus, among the considered parameters the HTC coefficient turned out to be the most significant.

It follows that water inflow to the lake is less and less determined only by the annual amount of precipitation, their relationship with evaporation in the warm season is more important. In The Fig. 7 shows graphs of changes in lake water levels and hydrothermal coefficient of Selyaninov for the corresponding period.

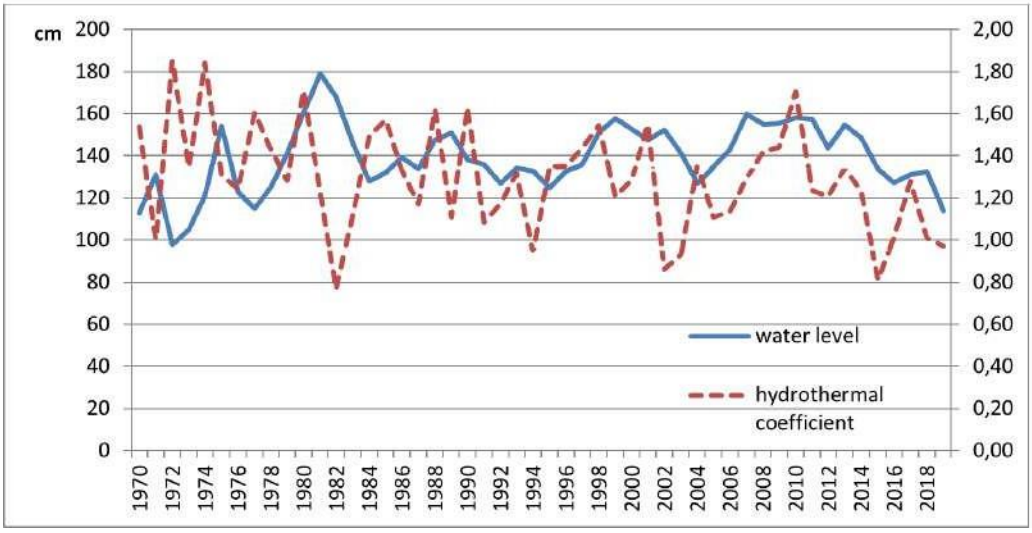

Fig. 7. Long-term dynamics of the water level of the Lake Svityaz and the hydrothermal coefficient.

As we can see from the graphs, these curves have not been consistent for a long time, but since 2005 their course has been synchronized. The correlation coefficient between these indicators for 2005-2018 is 0.74. That means, the water level in the lake becomes increasingly dependent on the dynamics of climatic condition, which, in particular, means a decrease in the sustainability of the hydro ecosystem. Most likely, this stability was previously provided by significant groundwater and underground water supply. Now with groundwater and underground water levels falling down, their stabilizing role for the Lake Svityaz is also declining.

Conclusions.

1. The water level of Lake Svityaz in 2019 reached the minimal values for almost 50 years of observations. The field surveys conducted in October 2019 showed that the shoreline receded in some areas of the lake at a distance of up to 90 m. The analysis of multispectral space images according to the NDWI index show a reduction in the area of the water mirror by 8-10%.

2. Comparison of climatic indicators for the period of 1970-1988 and of 2000-2018 showed that:

- the average annual precipitation indicator did not decrease either at the Svityaz meteorological station or in the region as a whole. At the same time, the number of days with precipitation decreased, especially in the warm period. In some years, the annual precipitation amount is significantly lower than the climatic norm. In 2019 most meteorological stations in the region recorded a negative deviation of the annual amount of precipitation;

- the average annual evaporation rate for Svityaz meteorological station increased by 16-32% (according to calculations by various methods), the largest increase is recorded in the period from April to October. Indicators for other weather stations reflect the same trend.

- integrated indicators of the ratio of precipitation and evaporation in the region have mainly also decreased, but they have significant spatial differences. For Svityaz, the average annual moisture content decreased by almost 20%, the hydrothermal coefficient (according to Selyaninov) – by 9%. The lowest indicators in the region in 2019 were recorded in the northern districts of Volyn region (including the territory of SNNP) and adjacent districts of Belarus.

3. The dynamics of the water level in the lake for the period of 1970-1988 did not show strong dependencies on the annual meteorological indicators. Since 2000, and especially clearly since 2005, the correlation of water levels with the hydrothermal coefficient has been significantly increasing. This is caused, firstly, by growing effect of increasing average annual and monthly air temperatures and increasing evaporation rates in the warm season; secondly, by reducing of the integrated ecological sustainability of natural wetlands and forest landscapes in the region, significantly changed over the past 50 years under the influence of anthropogenic activity; and thirdly, by the

decline in groundwater and underground water levels, which has occurred gradually in recent years, both under the influence of the global warming and a number of man-made factors.

The "butterfly effect" is well known: even minor events in the past can have a significant impact on the future. Large-scale drainage and reclamation works in the second half of the twentieth century in the area of Ukrainian Polissya, deforestation and other forms of economic development are likely to have reduced the sustainability of natural ecosystems, and they have been found to be very vulnerable to recent global climate change.

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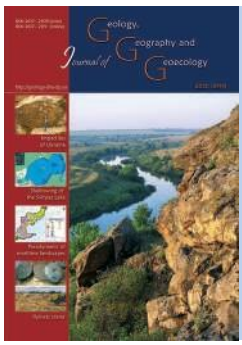

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Clustering of regional tourism service markets according to indicators of the functioning of subjects of tourism activity

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Abstract. Clustering of regional tourism service markets of Ukraine is performed according to the indicators of functioning of subjects of tourism activity (number of subjects of tourism activity; number of stuff members of tourist activities; income from tourism; number of tourists served by tour operators and travel agents; cost of travel packages sold). The clustering was performed in the software STATISTICA 10, the Ward method was chosen as the clustering algorithm, and the Euclidean distance was chosen as a measure of distance. The calculations made it possible to distinguish 6 clusters of regional tourism service markets of Ukraine, which are formed at a threshold distance of 0.5, namely: cluster 1 is Kyiv city, cluster 2 is Zaporizhia, Kyiv, Poltava, Ivano-Frankivsk regions, cluster 3 is Dnipropetrovsk , Lviv regions, cluster 4 is Odessa, Kharkiv regions, cluster 5 is formed from Zhytomyr, Ternopil, Chernihiv, Kirovograd and Luhansk regions, cluster 6 unites Vinnytsia, Chernivtsi, Donetsk, Cherkasy, Transcarpathian, Rivne, Khmelnytsky, Volyn, Sumy, Kherson and Mykolaiv regions. The clusters on the vertical dendogram of hierarchical clustering are visualized, the spatial distribution of clusters of regional markets of tourist services is shown on the map of Ukraine. It is established that the high degree of regional differentiation of tourist service markets in Ukraine is caused by differences in the distribution of natural resources, climatic features of the regions, cultural and historical conditionality, and uneven placement of transport, communication, resort and entertainment infrastructures, asymmetrical distribution of recreational resources. It is suggested to take into account the restrictions of development of regional tourism service markets of Ukraine (clusters of regional tourism service markets) in terms of spatial polarization, to distribute them into internal (historically-formed basic and innovative determinants) and external ones.

Keywords: tourism, tourism service market, service sector, cluster analysis, subjects of tourism activity, tourism activity, spatial polarization

Кластеризація регіональних ринків туристичних послуг за показниками функціонування суб'єктів туристичної діяльності

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Анотація. Здійснено кластеризацію регіональних ринків туристичних послуг України за показниками функціонування суб'єктів туристичної діяльності (кількість суб›єктів туристичної діяльності; кількість штатних працівників суб'єктів туристичної діяльності; дохід від надання туристичних послуг; кількість туристів, обслугованих туристичними операторами та туристичними агентами; вартість реалізованих туристичних путівок). Кластеризацію було здійснено у програмному продукті STATISTICA 10, у якості алгоритму кластеризації було обрано метод Уорда, мірою відстані обрано Евклідову відстань. Проведені розрахунки дозволили виокремити 6 кластерів регіональних ринків туристичних послуг України, які утворюються при пороговій відстані у 0,5, а саме: кластер 1 – м. Київ, кластер 2 – Запорізька, Київська, Полтавська, Івано-Франківська області, кластер 3 – Дніпропетровська, Львівська області, кластер 4 – Одеська, Харківська області, кластер 5 утворено з Житомирської, Тернопільської, Чернігівської, Кіровоградської та Луганської області, кластер 6 об'єднує Вінницьку, Чернівецьку, Донецьку, Черкаську, Закарпатську, Рівненську, Хмельницьку, Волинську, Сумську, Херсонську та Миколаївську області. Візуалізовано виокремлені кластери на вертикальній дендограмі ієрархічної кластеризації, просторовий розподіл кластерів регіональних ринків туристичних послуг відображено на карті України. Встановлено, що високий ступінь регіональної диференціації ринків туристичних послуг Україні обумовлений відмінностями в розподілі природних ресурсів, кліматичними особливостями регіонів, культурно-історичною обумовленістю, нерівномірністю розміщення транспортної, комунікаційної, курортно-

розважальної інфраструктури, асиметрією розподілу рекреаційних ресурсів тощо. Запропоновано облік обмежень розвитку регіональних ринків туристичних послуг України (кластерів регіональних ринків туристичних послуг) в умовах просторової поляризації здійснювати розподіливши їх на внутрішні (історично-сформовані базові та інноваційні детермінанти) і зовнішні.

Ключові слова: туризм, ринок туристичних послуг, сфера послуг, кластерний аналіз, суб'єкти туристичної діяльності, туристична діяльність, просторова поляризація

Introduction. The high degree of regional differentiation of the tourist service markets in Ukraine makes the usage of unified approaches to the tourism development management and regulation ineffective. The achieved strategic goals of the state policy in the field of tourism, coherences and satisfaction of interests of the tourism activity subjects and the state is possible through the development and implementation of optimal specific models of regional support to the development of business processes in the tourism industry. In this regard, the question of identifying clusters of regional tourist services markets of Ukraine similar in tendencies and indicators of tourism activity is urgent. The use of cluster analysis and profiling of each selected segment can serve as an informational and analytical basis for working out effective strategies and models for the development of regional tourism service markets.

The use of cluster analysis and clustering methods has become widespread in the tourism industry, both in the works of domestic scientists and foreign researchers. L. Golovkova, Yu. Yuhnovska (Golovkova, Yuhnovska, 2019) propose an algorithm for the formation and development of the tourism industry of the region on the basis of a cluster approach, insist that the structure of the tourism cluster of the region should be based on enterprises (organizations, firms) that are geographically located, tourist infrastructure, local labor markets and tourist product, which is a geographical and historical component of an appropriate region. The influence of tourism clustering on the formation of regional image, the spread of clustering processes through the promotion of the image of the territory is raised in the work of S. Kolyadenko (Kolyadenko, 2018). N. Andrusiak (Andrusiak, 2014) explores the general trends in the development of national and cross-border recreational and tourism clusters as effective instruments for interregional and international cooperation. A cluster analysis of tourist flows by cross-section of regions of Ukraine was carried out in the work of D. Ocheretin (Ocheretin, 2015), the task of which is to find similar groups of objects in the sample and to identify the location of each region in the tourist flow. O.Chernega, G. Gorina, O. Romanukha, G. Bohatyryova, K. Nikolenko (Chernega, Gorina, Romanukha, Bohatyryova, Nikolenko, 2019) zoned the territory of Ukraine for the development of cultural and educational tourism, which is based on the calculation of average data on the number of museums by region, analysis of their visits and volume of tourist flows. N. Ivanova (Ivanova, 2017) investigates the socio-economic indicators of the development of the regions of Ukraine in order to identify the homogeneity of objects (regions) of the crisis management system with the help of using cluster analysis methods. A. Okhrimenko (Okhrimenko, 2013) substantiates the urgency and necessity of the development of tourist clusters at the regional level, emphasizes their advantages and importance.

A number of national scientists who use cluster analysis and clustering methods in their studies place emphasis in their works on certain regions of Ukraine. Thus, A. Parfinenko, K. Bosenko (Parfinenko, Bosenko, 2018) explore the potential of tourism clustering of Podilskyi region of Ukraine, V. Hotra (Hotra, 2013) outlines the stages and levels of clustering of the Transcarpathian tourism business in rural development, P. Romaniv (Romaniv, 2017) studies the cluster model of managing tourist activity of Lviv region, and also analyzes the role of cluster entities in the economic development of the regions. O. Mykhailiuk, I. Davidenko (Mykhailiuk, Davidenko, 2018) carry out the analysis of existing and perspective clusters in the tourism sphere of Odessa region, offer directions of tourist activity improvement in the region by taking into account the clustering process.

Cluster analysis and clustering methods are widely used by foreign scientists in studying tourism at all economic levels of its implementation. J. Chávez, A.I. Zamora Torres, M. C. Torres (Chávez, Zamora Torres, Torres, 2016) mainly focuse on the analysis of 14 competitiveness tourism factors for 20 country members of the Asia-Pacific Economic Cooperation (APEC) forum. The authors analyze secondary data from the Travel and Tourism Competitiveness Index to create clusters, and then multidimensional scaling techniques were employed for detecting the more or less effective determinants of destination competitiveness. T. Yalçınkaya, T. Güzel (Yalçınkaya, Güzel, 2019) focuses on general overview of tourism clusters. Authors propose the explanation what a tourism cluster is, how it is processed, how its network system functions and how tourism clusters are classified. G. Koľveková, E. Liptáková, Ľ. *Štrba*, B. Kršák, C. Sidor, M. Cehlár, S. Khouri, M. Behún

(Koľveková, Liptáková, *Štrba*, Kršák, Sidor, Cehlár, Khouri, Behún, 2019) discusse the fusion of 54 regions of Central and Eastern Europe (Czech Republic, Slovakia, Hungary, Poland, Estonia, Lithuania, Latvia, Slovenia, Romania, and Bulgaria) into clusters according to the selected accommodation tourism indicators used by the European Statistical Agency (Eurostat) to evaluate tourism. The cluster analysis resulted in the definition of six clusters consisting of regions with similar indicators' statistics characteristics. D. Lascu, L. Manrai, A. Manrai, A. Gan (Lascu, Manrai, Manrai, Gan, 2018) identifie traits of the most attractive tourism destinations in Spain using a two-step cluster analysis to ascertain the relative importance of natural, cultural, and dual attractions to target consumers. A. Ramiresa, F. Brandaob, A.C. Sousa (Ramiresa, Brandaob, Sousa, 2018) segments international tourists visiting the World Heritage City of Porto based on their travel motivations relating to specific destination attributes, as well as gauging their satisfaction with the tourist experience. N. Iswandhani, M. Muhaji (Iswandhani, Muhaji, 2018) used K-means cluster analysis of tourist destination in special region of Yogyakarta using spatial approach and social network analysis.

The result of this research is the determination of the top-10 most popular destinations in Yogyakarta, map of html-based tourist destination distribution consisting of 121 tourist destination points and forms 3 clusters. J. Dew (Dew, 2018) examined different segments of visitors to Tanzania with respect to their values around sustainability through a combination of non-hierarchical and hierarchical cluster analyses. A follow-up analysis using ANOVA and Chi-square indicates that three clusters are significantly different in their sustainable values, their travel motives, and their demographics. J. Rodríguez, I. Semanjski, S. Gautama, N. Van de Weghe, D. Ochoa (Rodríguez, Semanjski, Gautama, Van de Weghe, Ochoa, 2018) developed and implemented a hierarchical clustering approach for smartphone geo-localized data to detect meaningful tourism related market segments. The application of the proposed approach in the Province of Zeeland in the Netherlands allowed to distinguish two major clusters and four sub-clusters which we were able to interpret based on their spatial-temporal patterns and the recurrence of their visiting to the region.

Content analysis of modern domestic and foreign researches devoted to diagnostics of tourist activity allowed to confirm the hypothesis about widespread use of methods of multidimensional statistical analysis, in particular cluster. Researchers subjected to clustering as individual tourist enterprises or organizations and regional tourist markets of whether the same state and tourist regions.

At the same time, it is established that in Ukraine the process of implementation of the cluster model of organization of tourist activity is in the stage of formation. Clusters combine mainly tourism entities, while the regional aspect both of the diagnostics of tourism markets and establishment of the joint strategies and the models of regional travel market development with similar historically formed basic and innovation determinants is ignored.

The aim is to carry out cluster analysis of the regional tourism market indicators for the functioning of tourism, which should improve diagnostic approaches to market and create a basis for study strategies and development models.

Material and research methods. The theoretical basis of the study were the provisions of the theory of tourism and tourismology (spatial model of the tourism travels (displacement), structural models of tourism, spatial models of tourism development), economic geography, regional economy, economic theory, macro and micro economics, works of leading domestic and foreign scientists on the tourism development issues.

To achieve this purpose, the following research methods were used in the work: generalization, systematization (for content analysis of the works of domestic and foreign scientists, devoted to the use of cluster analysis and clustering methods in tourism industry studies); analysis and synthesis (to determine the features that clustered the sample objects (regional tourist services markets)); method of cluster analysis based on the integration of objects (regional tourist services markets) into clusters, using a measure of similarity or the distance between them using the STATISTICA 10 software (StatSoft, USA, 2014) (for grouping regional markets of tourist services of Ukraine by indicators of functioning of subjects of tourist activity); graphical and tabular methods (for visualization and ability to see statistical material); cartographic method (to illustrate clusters of regional tourist services markets of Ukraine).

The reliability of the obtained results is ensured by the use of official data of the State Statistics Service of Ukraine. However, it should be noted that the composition and number of clusters depends on the selected partition criteria. In our case, the characteristics by which the grouping (the breakdown criteria) are the indicators selected by the authors from the data of the statistical collection of the State Statistics Service of Ukraine "Tourism in Ukraine in 2018" and which, according to the authors, most reflect the func-

tioning of the subjects of tourism activity. However, the absence/presence of certain features of clusters in a given set can change their structure. Also, the composition and number of clusters will change significantly, taking into account the data of the temporarily occupied territory of the Autonomous Republic of Crimea, Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions.

Results and their analysis. Taking into account the regional specificity of the tourism development should not be based only on the administrative-territorial division of the country. Regional markets for tourism services in Ukraine with similar trends in tourism development may not be related by territorial or administrative feature. It is proposed to carry out the identification of groups of regions with similar tendencies of development of tourist entities and further development of the most relevant and popular development strategies and models by cluster analysis.

24 regions of Ukraine and the city of Kyiv serve as the sampling objects, which features were used for clustering made in 2018 are: the number subjects of tourist activity, the number of staff members of tourist activities, income from tourism, the number of tourists served by tour operators and travel agents, the cost of travel packages sold in different regions.

Initial statistics for cluster analysis of the regional tourism market is presented in the Table 1.

Previous valuation of output data to eliminate differences in performance units made by the formula:

$$z = \frac{(x-\mu)}{\sigma}, \quad (1)$$

where z – the value of the standard normalized distribution,

x – the value of the output distribution,

μ – the average value of the original distribution,

σ – standard deviation of the original distribution.

Dendogram hierarchical clustering regional travel market was built on the software STATISTICA 10 (StatSoft, USA, 2014) by consecutive Clustering of the nearest first, and then of more and more distant from each other objects. The Euclidian distance was selected as the clustering algorithm. Euclidean distance matrix for the analyzed object (regional tourism market) given in the table 2.

To determine the number of clusters enlarged it is advisable to choose a threshold distance of 1 or higher, while for more detailed fundamental analysis of the tourism services market it is needed to develop the local development strategies advisable to choose a threshold distance of 0.5 and lower, will determine the optimal composition of cluster indicators of activity of the regional tourism market. The built dendogram is shown in the Fig. 1.

Table 1. Initial statistics for cluster analysis of the regional tourism market of Ukraine, 2018 *(compiled by the author using (Statistical yearbook "Tourist activity in Ukraine", 2018))*

Region	Number of subjects of tourist activity (units)	Number of staff members of tourist activities (persons)	Income from tourism (ths. UAN)	Number of tourists served by tour operators and travel agents (persons)	The cost of travel packages sold (ths. UAN)
Vinnytska	87	202	44367.8	42178	50789.1
Volynska	74	100	23620.1	21807	41564.8
Dnipropetrovska	416	748	99660.1	116981	550359.9
Donetska	93	164	45414.5	28425	139199.5
Zhytomyrska	63	67	10550.6	17957	94454.6
Zakarpatska	91	125	29122.4	25348	101795.9
Zaporizka	188	309	45976.2	56374	396231.8
Ivano-Frankivska	128	554	453399.9	55781	61754
Kyivska	217	339	58981.2	66385	289505.1
Kirovohradska	54	58	16571.6	11556	39793
Luhanska	29	39	7461	6261	5286.5
Lvivska	342	811	511590.4	182255	386274.4
Mykolaivska	87	72	16583.5	19002	93039.6
Odeska	270	741	202190.7	81381	532000.4
Poltavska	155	217	25604.5	32007	70424.8
Rivnenska	93	135	19992.3	22027	77158
Sumska	79	74	15788.2	16178	46447.6
Ternopilska	63	104	12345.8	13103	37343.4
Kharkivska	266	443	86603.2	62232	344204
Khersonska	80	136	53914	26130	34531.1
Khmelnytska	89	120	12610.6	25738	38228
Cherkaska	101	167	22722.1	26383	42603.4
Chernivetska	77	194	28990.1	29562	128982.4
Chernihivska	58	97	12074.5	22306	66293.7
Kyiv	1093	5861	19769786	3550090	13398039.7

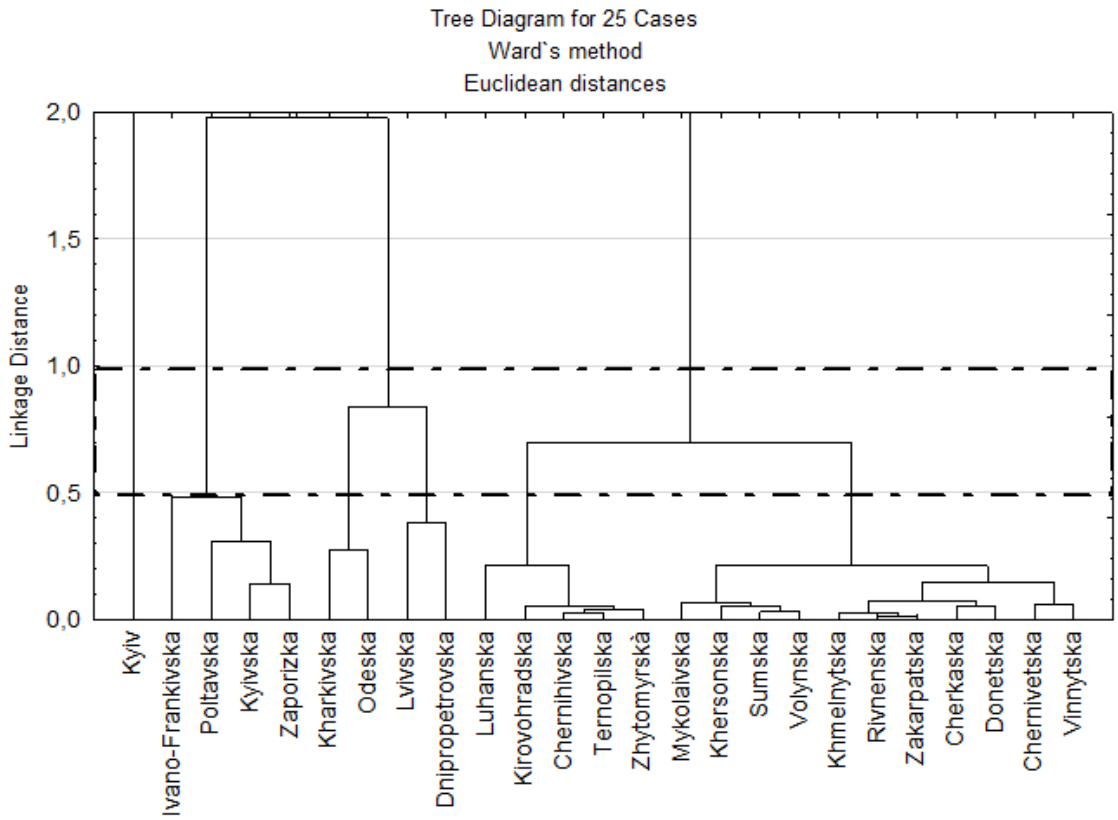

Fig. 1. Dendogram of hierarchical clustering of regional tourism service markets of Ukraine (*compiled by the author*)

At a threshold of 0.5, 6 clusters are formed in the tourist services market of Ukraine. *Cluster 1* is Kyiv, which according to all indicators of the functioning of the subjects of tourist activity (number of subjects of tourist activity; number of stuff members of tourist activity; income from tourism; number of tourists served by tour operators and travel agents; the cost of travel package sold) is in the first place. *Cluster*

Table 2. Euclidean distance matrix for regional tourist services markets of Ukraine (*compiled by the author*)

Region	Vinnytska	Volynska	Dnipropetrovska	Donetska	Zhytomyrska	Zakarpatska	Zaporizka	Ivano-Frankivska	Kyivska	Kirovohradska	Luhanska	Lvivska	Mykolaivska	Odeska	Poltavska	Rivnenska	Sumska	Ternopilska	Kharkivska	Khersonska	Khmelnytska	Cherkaska	Chernivetska	Chernihivska	Kyiv
Vinnytska	**0.00**	0.11	1.62	0.06	0.17	0.08	0.50	0.38	0.62	0.20	0.31	1.33	0.12	0.99	0.32	0.07	0.12	0.15	0.87	0.07	0.08	0.08	0.06	0.17	11.02
Volynska	0.11	**0.00**	1.70	0.11	0.06	0.09	0.58	0.48	0.71	0.10	0.22	1.42	0.07	1.09	0.39	0.09	0.03	0.05	0.95	0.04	0.07	0.14	0.09	0.08	11.11
Dnipropetrovska	1.62	1.70	**0.00**	1.60	1.76	1.62	1.13	1.37	1.00	1.80	1.92	0.38	1.65	0.68	1.32	1.61	1.69	1.75	0.75	1.67	1.63	1.57	1.66	1.77	10.10
Donetska	0.06	0.11	1.60	**0.00**	0.16	0.04	0.47	0.39	0.60	0.21	0.32	1.31	0.09	0.98	0.29	0.04	0.11	0.16	0.84	0.08	0.06	0.05	0.08	0.18	11.02
Zhytomyrska	0.17	0.06	1.76	0.16	**0.00**	0.14	0.63	0.54	0.76	0.05	0.16	1.48	0.11	1.14	0.45	0.15	0.08	0.04	1.01	0.10	0.13	0.20	0.13	0.04	11.14
Zakarpatska	0.08	0.09	1.62	0.04	0.14	**0.00**	0.49	0.43	0.62	0.18	0.30	1.34	0.05	1.01	0.31	0.02	0.08	0.13	0.87	0.06	0.03	0.06	0.09	0.16	11.05
Zaporizka	0.50	0.58	1.13	0.47	0.63	0.49	**0.00**	0.39	0.14	0.68	0.79	0.87	0.53	0.54	0.22	0.48	0.57	0.63	0.38	0.54	0.51	0.45	0.54	0.65	10.72
Ivano-Frankivska	0.38	0.48	1.37	0.39	0.54	0.43	0.39	**0.00**	0.47	0.57	0.66	1.04	0.48	0.71	0.34	0.42	0.49	0.51	0.66	0.44	0.44	0.38	0.41	0.53	10.75
Kyivska	0.62	0.71	1.00	0.60	0.76	0.62	0.14	0.47	**0.00**	0.81	0.92	0.74	0.66	0.44	0.32	0.61	0.69	0.75	0.25	0.67	0.63	0.57	0.67	0.78	10.67
Kirovohradska	0.20	0.10	1.80	0.21	0.05	0.18	0.68	0.57	0.81	**0.00**	0.12	1.52	0.16	1.19	0.49	0.19	0.12	0.06	1.05	0.14	0.17	0.24	0.17	0.04	11.17
Luhanska	0.31	0.22	1.92	0.32	0.16	0.30	0.79	0.66	0.92	0.12	**0.00**	1.63	0.27	1.30	0.61	0.31	0.24	0.17	1.17	0.25	0.29	0.35	0.27	0.15	11.24
Lvivska	1.33	1.42	0.38	1.31	1.48	1.34	0.87	1.04	0.74	1.52	1.63	**0.00**	1.38	0.38	1.05	1.33	1.41	1.47	0.52	1.38	1.35	1.28	1.37	1.49	10.12
Mykolaivska	0.12	0.07	1.65	0.09	0.11	0.05	0.53	0.48	0.66	0.16	0.27	1.38	**0.00**	1.05	0.34	0.06	0.04	0.12	0.90	0.07	0.05	0.11	0.12	0.14	11.09
Odeska	0.99	1.09	0.68	0.98	1.14	1.01	0.54	0.71	0.44	1.19	1.30	0.38	1.05	**0.00**	0.73	1.00	1.08	1.13	0.27	1.05	1.02	0.95	1.03	1.15	10.35
Poltavska	0.32	0.39	1.32	0.29	0.45	0.31	0.22	0.34	0.32	0.49	0.61	1.05	0.34	0.73	**0.00**	0.30	0.38	0.44	0.56	0.36	0.32	0.25	0.36	0.46	10.89
Rivnenska	0.07	0.09	1.61	0.04	0.15	0.02	0.48	0.42	0.61	0.19	0.31	1.33	0.06	1.00	0.30	**0.00**	0.09	0.14	0.86	0.06	0.03	0.05	0.09	0.17	11.05
Sumska	0.12	0.03	1.69	0.11	0.08	0.08	0.57	0.49	0.69	0.12	0.24	1.41	0.04	1.08	0.38	0.09	**0.00**	0.08	0.94	0.06	0.06	0.13	0.11	0.10	11.11
Ternopilska	0.15	0.05	1.75	0.16	0.04	0.13	0.63	0.51	0.75	0.06	0.17	1.47	0.12	1.13	0.44	0.14	0.08	**0.00**	1.00	0.09	0.12	0.19	0.11	0.03	11.13
Kharkivska	0.87	0.95	0.75	0.84	1.01	0.87	0.38	0.66	0.25	1.05	1.17	0.52	0.90	0.27	0.56	0.86	0.94	1.00	**0.00**	0.91	0.88	0.81	0.91	1.02	10.53
Khersonska	0.07	0.04	1.67	0.08	0.10	0.06	0.54	0.44	0.67	0.14	0.25	1.38	0.07	1.05	0.36	0.06	0.06	0.09	0.91	**0.00**	0.05	0.10	0.06	0.11	11.08
Khmelnytska	0.08	0.07	1.63	0.06	0.13	0.03	0.51	0.44	0.63	0.17	0.29	1.35	0.05	1.02	0.32	0.03	0.06	0.12	0.88	0.05	**0.00**	0.07	0.09	0.15	11.07
Cherkaska	0.08	0.14	1.57	0.05	0.20	0.06	0.45	0.38	0.57	0.24	0.35	1.28	0.11	0.95	0.25	0.05	0.13	0.19	0.81	0.10	0.07	**0.00**	0.12	0.21	11.02
Chernivetska	0.06	0.09	1.66	0.08	0.13	0.09	0.54	0.41	0.67	0.17	0.27	1.37	0.12	1.03	0.36	0.09	0.11	0.11	0.91	0.06	0.09	0.12	**0.00**	0.13	11.04
Chernihivska	0.17	0.08	1.77	0.18	0.04	0.16	0.65	0.53	0.78	0.04	0.15	1.49	0.14	1.15	0.46	0.17	0.10	0.03	1.02	0.11	0.15	0.21	0.13	**0.00**	11.14
Kyiv	11.02	11.11	10.10	11.02	11.14	11.05	10.72	10.75	10.67	11.17	11.24	10.12	11.09	10.35	10.89	11.05	11.11	11.13	10.53	11.08	11.07	11.02	11.04	11.14	**0.00**

2 is formed by Zaporizhzhya, Kyiv, Poltava, Ivano-Frankivsk regions. *Cluster 3* and *Cluster 4* consist of two sample objects - Dnipropetrovsk, Lviv and Odesa, Kharkiv regions respectively. *Cluster 5* unites the Zhytomyr, Ternopil, Chernihiv, Kirovograd and Luhansk regions. *Cluster 6* is the most numerous, grouping eleven regions of Ukraine, namely Vinnytsia, Chernivtsi, Donetsk, Cherkasy, Transcarpathian, Rivne, Khmelnytsky, Volyn, Sumy, Kherson and Mykolaiv regions (table 3).

Accounting constraints of the development of the regional tourist market of Ukraine (regional cluster of tourist market) in terms of spatial polarization is advisable by dividing them into *internal and external. Internal constraints* delineate the boundary of individual travel market in the region (regions, clusters) caused by the imperfection or absence of endogenous determinant of the market, which in turn is advisable to distinguish between the *historically-formed base* and *innovative determinants* (Horina, 2016).

Table 3. Clustering regional tourism market of Ukraine (*compiled by the author*)

Threshold – 0.5			**Threshold - 1**		
Cluster	Cluster integration level	Cluster	Cluster integration level	Cluster	Cluster integration level
1	*2*	*3*	*4*	*5*	*6*
Cluster 1	-	Kyiv	Cluster 1	-	Kyiv
Cluster 2	0.4865010	Zaporizka. Kyivska. Poltavska. Ivano-Frankivska	Cluster 2	0.4865010	Zaporizka, Kyivska, Poltavska Ivano-Frankivska
Cluster 3	0.3802633	Dnipropetrovska. Lvivska	Cluster 3	0.7004833	Vinnytska, Chernivetska, Donetska, Cherkaska, Zakarpatska, Rivnenska, Khmelnytska, Volynska, Sumska, Khersonska, Mykolaivska, Zhytomyrska, Ternopilska, Chernihivska, Kirovohradska, Luhanska,
Cluster 4	0.2732135	Odeska. Kharkivska			
Cluster 5	0.2139298	Zhytomyrska. Ternopilska. Chernihivska. Kirovohradska Luhanska	Cluster 4	0.8406595	Dnipropetrovska, Lvivska, Odeska, Kharkivska
Cluster 6	0.2129407	Vinnytska, Chernivetska, Donetska, Cherkaska, Zakarpatska, Rivnenska, Khmelnytska, Volynska, Sumska, Khersonska, Mykolaivska			

It should be also noted that geography hasn't been used and isn't taken into account when combining regional travel market in clusters on indicators of functioning of tourist activity. Only economic indicators of activity were applied.

Regional differentiation of the development of tourist services markets of Ukraine is caused by "... differences in the distribution of natural resources, climatic features of the regions, cultural and historical conditionality, disproportional placement of transport, communication, resort and entertainment infrastructure, asymmetry of distribution of recreational resources" (Gorina, 2016) and other factors that shape spatial polarization. In this regard, the polarizing aspects of the spatial development of tourism, the causes and consequences of increasing imbalances and asymmetries in the structure of the tourism market, must be taken into account when forming strategies and models of market development.

Historically-formed determinants are revealed through the "… assessment of the imperfection localization or lack of necessary natural resource and socio-demographic factors for the development of the tourist service market, namely favorable geographical location and natural and climatic conditions, access to natural resources, optimal proximity to external borders / center, the availability of a sufficient number of skilled labor resources, the level of labor productivity caused by socio-cultural characteristics and ethnic composition of the population" (Gorina, 2016). Among the historically-formed determinants that influenced the formation of tourist services regional market clusters of Ukraine, natural resource determinants prevail, namely: provision and access to natural resources, favorable natural and climatic conditions, proximity to external borders.

Innovative determinants are revealed due to set of restraining restrictions that arise as a result of im-

perfection of institutional and infrastructural support for the formation of the tourist market (transport and sectorial infrastructure, organizational and institutional structures), heterogeneity and structural unevenness of the industrial and economic complexes, which ensures the low level of tourism, imperfect sectorial and regional development strategies. Among the innovative determinants that traditionally influence the formation of inequality in the development of tourist regions of the tourism service national market are the most influential: institutional and infrastructural determinants (transport and sectoral infrastructure), determinants of innovation (innovational and investment activity in the tourism industry), political and economic determinants (regional policy in the field of tourism; the presence of a tourism and recreational component in the development strategy of the region), integration determinants (degree of the region involvement in foreign economic activity; participation in relevant integration associations, cross-border cooperation in the field of tourism), globalization determinants (presence and position of large corporate structures in the region, namely the presence of international hotel nets, international tour operators, etc.; involvement in the international specialization and cooperation in the tourism industry; involvement in international trade, international investment processes, interregional competition).

External constraints are hindering integration, globalization and the development of the tourism market and are manifested in the absence of exogenous determinants of development. These restrictions mainly concern the national tourism market as a whole.

Analyzing the spatial distribution of clusters of regional tourist service markets of Ukraine, shown in the Figure 2, we can conclude about the prevailing lack of geographical proximity of the formed clusters. Only the cluster 6 is the exception as it combines more than 40% of the sample sites (eleven regions of Ukraine, namely Vinnytsia, Zaporizhia, Donetsk, Cherkassy, Transcarpathian, Rivne, Khmelnytsky, Lutsk, Sumy, Kherson and Mykolaiv regions), with common geographical boundaries in a limited space.

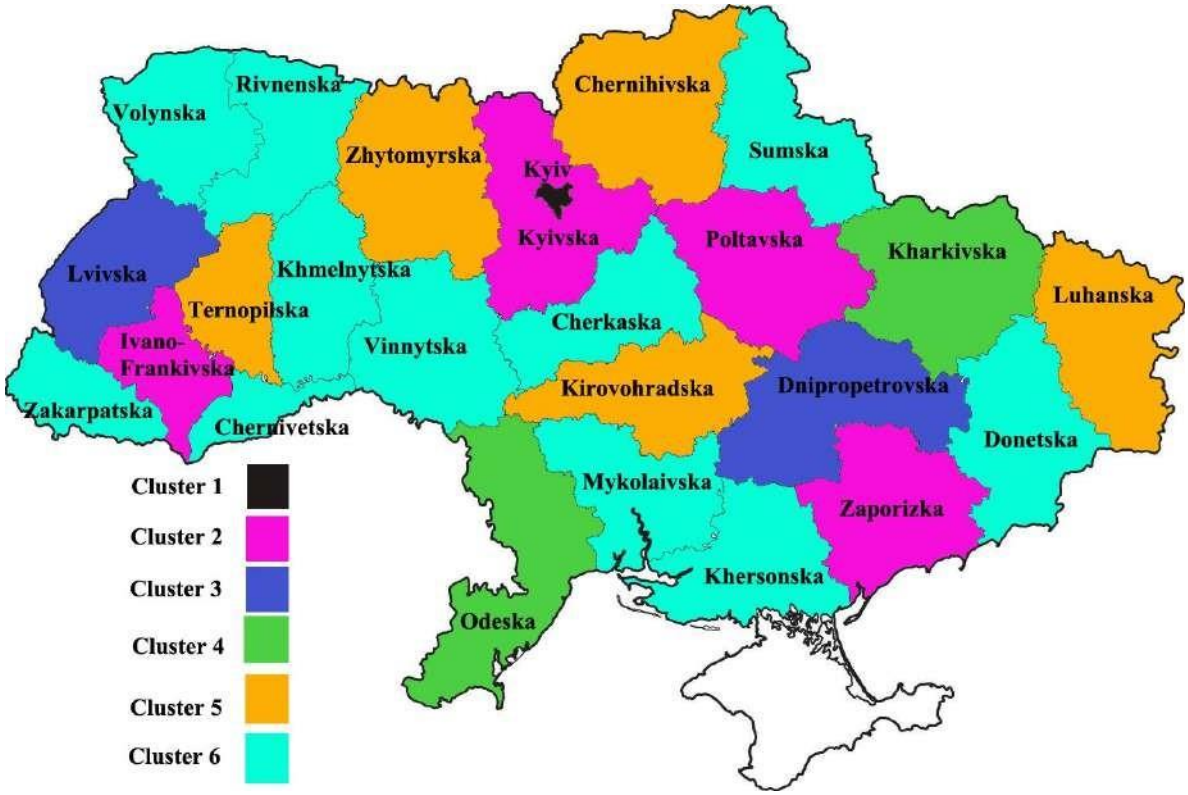

Fig. 2. Spatial distribution of regional clusters of tourism market of Ukraine (distance threshold - 0.5)

Cluster 1, which was established in Kyiv, is a center for tourism development, on the basis of which the main volume of tourist demand is formed, tourist infrastructure is concentrated, tourist flows are concentrated, major innovations in the Tourism sector are generated, and as a result of the spatial diffusion process, they are spread to other clusters / regional tourist service markets.

Further calculation of the cluster market shares in the tourist service market of Ukraine will allow to determine what place the cluster occupies in the relevant segment in relation to its competitors (other

Table 4. Market shares of clusters of regional tourism service markets of Ukraine, 2017

Cluster	Market share of the number of subjects of tourist activity, %	Market share of the number of staff members of tourist activities, %	Market share of the income from tourism, %	Market share of the number of tourists served by tour operators and travel agents, %	Market share of the cost of travel packages sold, %
Cluster 1	**25.46**	**49.35**	**91.42**	**77.90**	**78.51**
Cluster 2	16.03	11.95	2.70	4.62	4.79
Cluster 3	17.66	13.13	2.83	6.57	5.49
Cluster 4	12.49	9.97	1.34	3.15	5.13
Cluster 5	6.22	3.07	0.27	1.56	1.42
Cluster 6	22.15	12.54	1.45	6.20	4.65

clusters), to predict the further prospects of their development, to evaluate the effectiveness of cluster activities, etc.

The calculated market shares of 6 clusters, which were determined at a threshold distance of 0.5 (table 3) are given in the table 4. The objects of the cluster sample correspond to the column 3 of the table 3.

In terms of indicators by which the clusters were grouped and evaluated, we have the following results:

by market share of the cluster by the number of subjects of tourist activity, the largest market share belongs to the cluster 1 (25.46%), the smallest– to the cluster 5 (6.22%);

by market share of the cluster by the number of staff members of tourist activities, the largest market share belongs to the cluster 1 (49.35%), the smallest– to the cluster 5 (3.07%);

by market share of the cluster by income from tourism, the largest market share belongs to the cluster 1 (91.42%), the smallest – to the cluster 5 (0.27%);

by market share of the cluster by the number of tourists served by tour operators and travel agents, the largest market share belongs to the cluster 1 (77.90%), the smallest – to the cluster 5 (1.56%);

by market share of the cluster by the cost of travel packages sold, the largest market share belongs to the cluster 1 (78.51%), the smallest – cluster 5 (1.42%).

These data allow us to state that the largest market shares by all indicators belong to the cluster 1 (Kyiv), the smallest – to the cluster 5 (Zhytomyr, Ternopil, Chernihiv, Kirovograd, Luhansk regions).

Conclusions. It is determined that the disproportion of the distribution a redistribution of natural a recreational a socio-economic resource and the influence of historically formed and innovative determinants leads to uneven development of the tourist space. In this regard, it is concluded that the regional differentiation of the development of tourist services markets in Ukraine is caused by factors of formation of spatial polarization, which affect the spatial structure of the tourism system, cause and enhance its asymmetry and lead to the need to take into account the identified processes in the development of concepts and strategies of development markets.

The cluster analysis of regional tourist service markets according to the indicators of functioning of tourist entities (the number of subjects of tourist activity; the number of stuff members of tourist activities; income from tourism; the number of tourists served by tour operator an travel agents; the cost of travel packages sold) allowed to distinguish 6 clusters at a threshold distance of 0.5, namely: cluster 1 – Kyiv, cluster 2 – Zaporizhia, Kyiv, Poltava, Ivano-Frankivsk region, cluster 3 – Dnipropetrovsk, Lviv regions, cluster 4 – Odessa, Kharkiv regions, cluster 5 is formed from Zhytomyr, Ternopil, Chernihiv, Kirovograd and Luhansk regions, cluster 6 unites Vinnytsia, Chernivtsi, Donetsk, Cherkasy, Transcarpathian, Rivne, Khmelnitsky, Volyn, Sumy, Kherson and Mykolaiv regions. The clustering carried out can serve as the basis for the further evolution of strategies and models for the development of certain clusters.

Study of tendencies for the development of each cluster, determination of market share of clusters in the market of tourist services of Ukraine, in-depth and detailed analysis taking into account factors of formation of spatial polarization using the methods of multidimensional statistical analysis and other analytical methods may be the topic of further researches.

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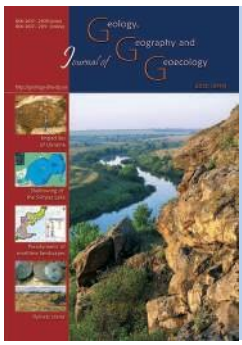

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Man-made pollution of the environment with coal dust as a result of operation and closure of coal mines

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Abstract. The technological processes of coal mining, enrichment and use, in particular coal combusting is accompanied by formation and release of significant amounts of dust and gases. Atmospheric air protection is one of the most urgent problems of the nowadays technological society, as scientific and technological progress and expansion of production is associated with an increase in negative anthropogenic impacts on the atmosphere. The paper presents a new solution to the current scientific problem of reducing carbon-containing dust content based on the disclosure of the laws of the aerodynamic interaction of dust and water flows in gravitational and electrostatic fields. The authors show in this study the causes of atmosphere pollution with coal-containing dust; main issues of atmospheric air protection at enterprises located in the controlled territory of Ukraine. The data of the first quarter of the 2020 year are presented in the research. The biggest part of the facilities that pollute the atmospheric air are focused in Donetsk and Lugansk regions. It is estimated that the air environment of the underground mine surface complex is filled with exhaust ventilation air of approximately 200.000 m^3 per minute with a dust concentration of approximately (5-7) mg / m^3, which is equal to 1.5 tons of dust per a day. It is here that the possibility of transporting pollutants over long distances is most often realized. Coarse dust discharged through the ventilation systems of mines is intensively deposited in the sanitary protection zones of mines. Fine dust is carried by the wind outside them, polluting the environment on the distance of up to 3500 m from the coal mine. Emissions of carbon dust into the atmosphere are almost always a major part of transboundary environmental pollution. Mine waste also poses an environmental threat. Technologies of reduction air pollution at the source of carbon-containing dust formation should be used in all new industries of economy. The results obtained reveal the mechanism of interaction of the sprayed liquid with coal dust and can be used in the development of new effective means of controlling the carbon-containing dust. The principles and practices of sustainable development, coupled with local research, will help to contain or eliminate health and environmental risks resulting from air pollution by carbon-containing dust.

Keywords: *air pollution, carbon-containing dust, environment, cardiovascular diseases, respiratory tract diseases, human health, dust prevention and control, dust reduction*

Техногенне забруднення довкілля вугільним пилом внаслідок функціонування і закриття вугільних шахт

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Анотація. Технологічні процеси вуглевидобутку, збагачення та використання, зокрема, спалювання вугілля, супроводжуються утворенням і виділенням значної кількості пилу і газів. Захист атмосферного повітря є однією з найактуальніших проблем сучасного технологічного суспільства, оскільки науково-технічний прогрес та розширення виробництва пов'язані зі збільшенням негативного антропогенного впливу на атмосферу. У статті представлено нове рішення актуальної наукової проблеми зменшення вмісту пилу, що містить вуглець, на основі розкриття законів аеродинамічної взаємодії потоків пилу та води в гравітаційному та електростатичному полях. В роботі наведено основні причини забруднення атмосфери вугільним пилом, основні проблеми охорони атмосферного повітря на підприємствах, які розташовані на підконтрольній території України. В роботі представлені дані за 1 квартал 2020 року. Левова частка підприємств-забруднювачів зосереджена у Донецькій та Луганській областях. За підрахунками встановлено, що повітряне середовище підземного шахтного поверхневого комплексу заповнюється витяжним вентиляційним повітрям, близько 200000 $м^3$ за хвилину з концентрацією пилу (5-7) мг/$м^3$, що дорівнює 1,5 т пилу на добу. Саме тут найчастіше реалізується можливість транспортування забруднювальних речовин на великі відстані. Грубий пил, що скидається через вентиляційні системи шахт, інтенсивно осідає в санітарно-захисних зонах шахт. Дрібний пил розноситься вітром поза ними, забруднюючи довкілля на відстані до 3500 м від вугільної шахти. Викиди вугле-

цевого пилу в атмосферу майже завжди є основною частиною транскордонного забруднення навколишнього середовища. Технології зменшення забруднення атмосферного повітря у джерелі вуглевмісного пилоутворення повинні використовуватися у всіх нових галузях промисловості. Отримані результати розкривають механізм взаємодії напилюваної рідини з вугільним пилом і можуть бути використані при розробці нових ефективних засобів боротьби з вуглевмісним пилом. Принципи та практики сталого розвитку в поєднанні з місцевими дослідженнями допоможуть стримати або усунути ризики для здоров'я та навколишнього середовища внаслідок забруднення атмосферного повітря пилом, що містить вуглець.

Ключові слова: забруднення повітря, пил, що містить вуглець, навколишнє середовище, серцево-судинні захворювання, хвороби дихальних шляхів, здоров'я людини, запобігання та контроль пилу, зменшення пилу

Statement of the Problem. The coal industry is a fundamental branch of Ukrainian economy. It is marked by quite complicated technological process, which essentially affect the environment.

The coal mining and coal processing entities are located in various regions of Ukraine. Because of the coal deposits they are located uneven, sometimes there is an excessive concentration of the coal facilities in particular regions.

The production activity in coal mining industry is accompanied by involving new deposits with sometimes-complicated hydrogeological conditions. All the aforementioned features with high concentration of coal mining and coal processing facilities define a continued man-made impact on state change and properties in particular of geological component and the environment in general. Such influence does not concern some production areas, but only overall in the production regions (Lysychenko, 2008).

The technological processes of coal mining, enrichment and use, in particular coal combusting is accompanied by formation and release of significant amounts of dust and gases. This leads the local atmosphere pollution and global negative influence, such as greenhouse effect, ozone depletion, oxidation of sediments, etc. The coal entities emission lots of dust, greenhouse gases (carbon monoxide CO, carbon dioxide CO_2, methane CH_4 and partially nitrogen dioxide NO_2) and acid gases (sulfur dioxide SO_2 and nitrogen oxides NO_x). The main sources of atmosphere pollution in coal industry are mines, enrichment factories, boiler rooms, fuel- combustion power plants, combustion waste dumps, etc. (Rudko, 2016).

The state of the atmosphere in Ukraine is defined as insufficient, in some regions e.g. Donetsk, Kharkiv, Dnipropetrivsk is extremely dangerous. According to statistic the main pollution sources for atmosphere are enterprises of the fuel and energy sector −36% of the total emissions, production companies − 35% and mining companies −25%. The main pollutants are oxides of carbon, nitrogen, sulfur dioxide, ammonia, phenols, formaldehyde, benzopyrene (Kuzin, 2010).

The polluted atmosphere has no boundaries, that is why this problem concerns not only the local inhabitants, but also city, region and even country.

Causes of air pollution:

emissions of toxic substances by industrial enterprises (cities Mariupol and Horlivka, Donetsk region – are so called "leaders" of Ukraine by the content of harmful substances in the air: formaldehyde, nitrogen dioxide, phenol, benz(a)pyrene, hydrogen fluoride, carbon monoxide, suspended solids);

greenhouse gas emissions and particulate emissions (soot) from chimneys;

evaporation of volatile toxic substances from settling tanks;

dust pollution (blowing of toxic substances from ash, slag and sludge dumps, heaps);

air pollution by emissions from stationary and mobile sources (ash from fuel-combustion power plants, formaldehyde, nitrogen dioxide, etc.) taking into account the falling of industrial production;

catastrophic situation with gassiness of cities, where technological equipment has not been updated for a long period (the number of equipment with a service life of 40 years or more exceeds 70%);

air pollution due to the activities of oil and gas companies and during the gas combustion in flares;

transboundary transportation of air pollutants into border areas (almost uncontrolled process due to the lack of sufficient number of mobile and stationary observation points).

The main part of sulfur dioxide (70%), nitrogen oxides (56%) and dust (52%) were released into the atmosphere by enterprises producing electricity, gas and water; hydrocarbons and volatile organic compounds (74%) − mining industry; carbon monoxide (70%) − manufacturing enterprises production companies (Lunova, 2018, 2019, 2020, Yermakov, 2000, 2019, Ulytskyi, 2019).

Although the pollutant emissions volumes have decreased recently, primarily due to the shutdown of many enterprises, in some industrial regions (especially in Donetsk-Prydniprovskyi region) they still significantly exceed the maximum allowable norms.

The particular concern is about more than a thousand harmful chemical companies, most of which are located in Donetsk and Luhansk regions. Over the last 10 years, the number of

children born here with disabilities has doubled. The poor state of the atmosphere is in the entire Donetsk-Dnieper region, also in Cherkasy, Kyiv and Odessa.

Due to the environmental pollution by the exhaust gases of internal combustion engines with harmful substances, entire regions, especially large cities, become a zone of ecological disaster for the population. The problem of harmful emissions from mobile emission sources is becoming more acute due to the continuous increase of the operated vehicles fleet, the consolidation of traffic network.

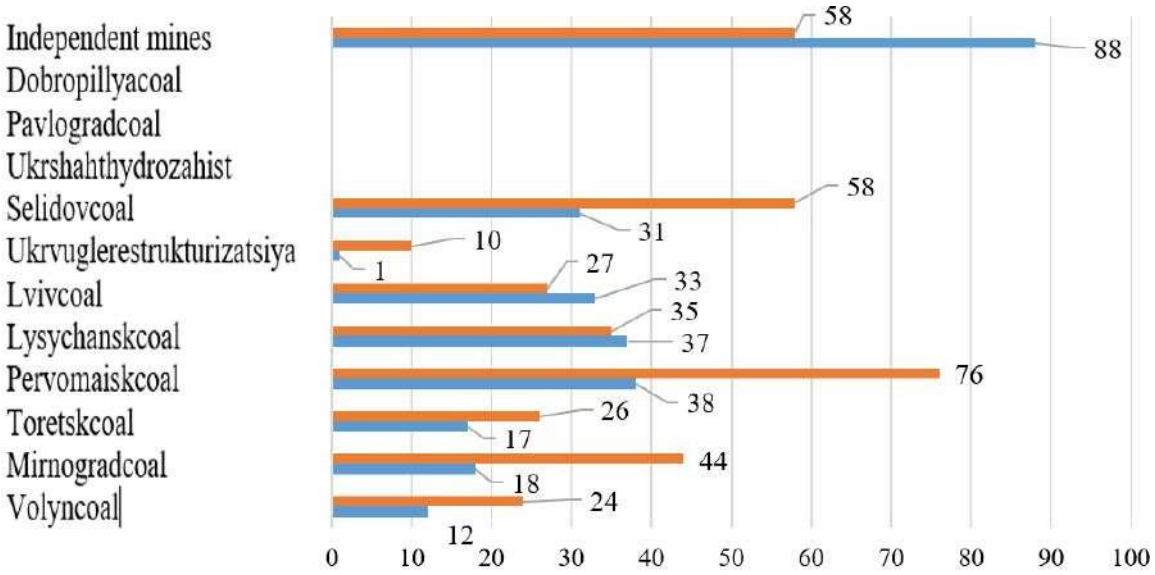

Fig.1. Distribution of organized and unorganized sources of dust pollutants emissions by coal mining enterprises for the first half of 2020 (units)

The main problems of air protection:

actual emissions of harmful substances into the atmosphere by technological cycles, entities of the mine complex and enterprises in general, performing their quantitative and qualitative assessment;

identification of priority areas for comprehensive work to reduce the harmful emissions;

introduction of new technologies to use the mine gas, degassing and ventilation systems.

intensification of works on reformation, extinguishing and reclamation of waste dumps;

creation of a monitoring system.

The main priorities in the field of air protection

implementation of EU standards and their adaptation to the regulatory system of Ukraine in the field of air quality;

reduction of the harmful effects of air pollution sources;

intensification of the state supervision to comply with the environmental protection legislation during the operation, construction of new and reconstruction of existing industrial enterprises and other facilities;

improvement of ventilation system, purification of indoor air conditioning systems;

improvement of air quality and air quality control in residential and public premises;

improvement of economic methods of air quality management.

At all enterprises located in the controlled territory of Ukraine, for the 1st quarter of 2020 there are 633 sources of pollutant emissions, 314 of which are organized and 358 - unorganized sources of emissions (Fig. 1). The biggest share of the polluting enterprises is concentrated in Donetsk and Luhansk regions (Bondar, 2020, Yermakov, 2020, Lunova, 2020).

As it can be seen from the Fig. 1, the largest number of emission sources are in the independent mines and SE "Pervomaiskcoal" − 146 and 114 units, respectively. During the first half of 2020, the coal industry enterprises released 93023.92 tons of pollutants into the atmosphere, 85118.05 tons of which are from organized and 7906.08 tons − from unorganized sources of emissions. The largest amount of pollutants − 46340.38 tons were produced by Lvivcoal in the first half of 2020. A significant amount of pollutants was produced by independent mines and SE "Mirnogradcoal", 22747.56 and 13364.80 tons, respectively. The lowest amount of pollutants in

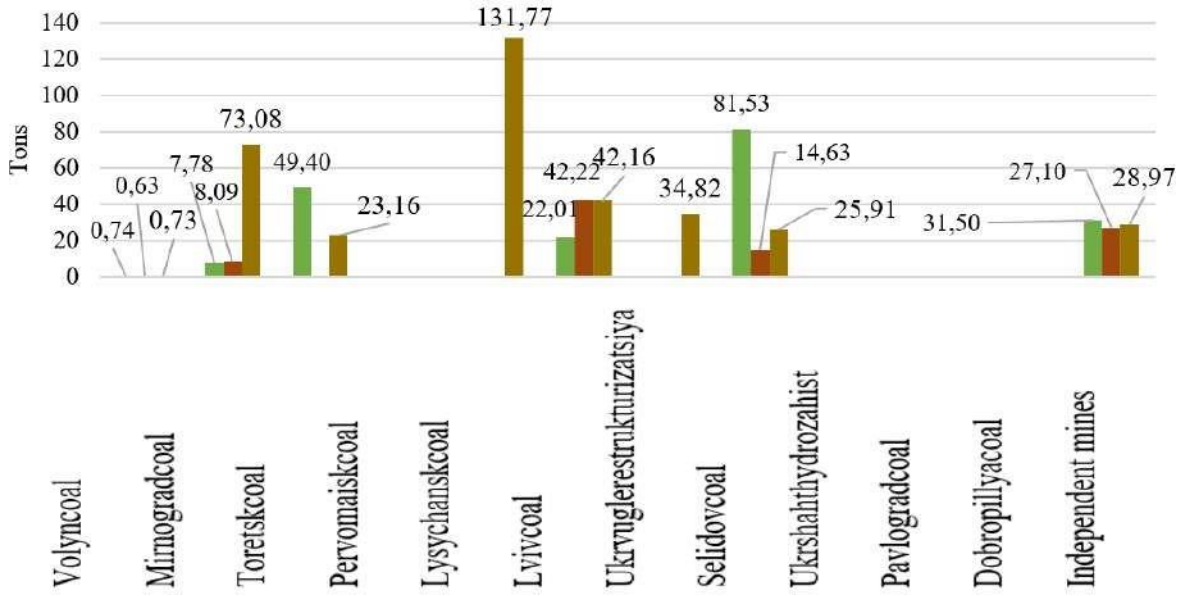

Fig. 2. Dust pollutants of coal mining enterprises

Coal-rock dust

Rock dust (inorganic SiO_2)

Coal dust

2020 was emitted by SE "Volyncoal" − 12.20 tons. Emissions of coal mining enterprises are shown in the Fig. 2. PJSC "Lysychanskcoal" emits the most solid pollutants − 1137.87 tons, and the least - SE "Volyncoal" – 7.34 tons.

Methodology & Theoretical Orientation. Theoretical and laboratory studies, experimental measurements, calculation for determining the probability of dust formation, mathematical planning (a second-degree D-optimal plan was used for construction the mathematical model), graph-analytical and mathematical planning methods.

Discussion. Coal mining enterprises are powerful sources of pollutant emissions into the atmosphere. As a result of the operation of coal mining and processing plants, significant amounts of carbon-containing dust enter the atmosphere. Researchers estimate that the air environment of the underground mine's surface complex is filled every minute with approximately 200,000 m^3 of exhaust ventilation air having a dust concentration of approximately (5-7) mg/m^3, which equals to 1.5 tons of dust per a day. This is where a long-range transportation of pollutants is most often possible. Coarse dust discharged through the ventilation systems of mines intensively settles within the sanitary protection zones of mines. Fine dust is carried on long distances by the wind beyond their limits, polluting the environment at a distance of up to 3500 m from the coal mine. Carbon dust emissions into the atmosphere are almost always a major part of transboundary environmental pollution. The mine wastes are also an environmental threat.

Coal dust consists of fine coal powder, which is formed during drilling, blasting, crushing, screening, crumbling, taking into account its fragile nature, mechanical and flowing transportation of coal and coal products. Air quality has the potential to be impacted by the coal dust emissions from coal mining activities, the transportation of coal from mines to designated ports and the loading operations at the port's export terminals.

Carbon-containing dust degrades air quality and ruthlessly distresses the natural bio-network and ecosystems and also has a serious impact on human health. Carbon-containing dust is a factor in increasing mortality from heart and respiratory diseases, decrease in pulmonary function of children and adults with the development of obstructive respiratory disease, and the increase in the frequency of symptoms. Health effects are associated with both short-term and long-term impact of dust particles.

The environmental risk of carbon-containing dust emissions necessitates measures to dust off mine ventilation streams and reduce dust emissions into the atmosphere. To reduce the environmental hazard of coal mine dusts (carbon-containing dust), it is recommended that they are localized using dispersed water.

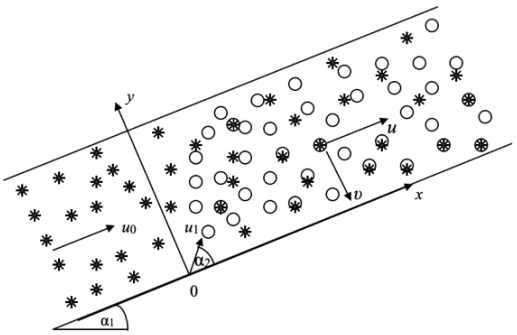

Fig. 3. Scheme of motion and mechanical interaction of the sprayed liquid (circles) with carbon-containing dust (asterisks) in an incline working area

Therefore, the disclosure of the peculiarities of the influence of factors on the effectiveness of the processes of interaction of dispersed water jets with carbon-containing dust in environmental pollution prevention technologies is an urgent problem, the solution of which is a prerequisite for scientific and technological progress in the field of environmental safety.

Theoretical and laboratory studies, experimental measurements, calculation for determining the probability of dust formation, mathematical planning (a second-degree D-optimal plan was used for construction the mathematical model), graph-analytical and mathematical planning methods.

When studying the dynamics of dust and dispersed water flows, we will consider dust particles and droplets of liquid as separate objects moving in the ventilation stream.

Let's choose the coordinate axes (Figure 3): x − is the longitudinal coordinate along the movement of the ventilation stream, starting from the place of creation of the dust stream (location of the combine) or from the location of the water flare, y − the transverse coordinate from the bottom to the top starting from the beginning, near the production soil (Gorobei, 2015, 2018, 2020).

The equation of the motion of a solid or liquid body in the field of gravity has the form:

$$m_i \frac{d\vec{U}}{dt} = m_i \vec{g} - \vec{W} \qquad (1)$$

where m_i – mass i – i – dust or liquid droplets, kg;

$\vec{U}$ – vector of relative velocity of a particle or droplet, m / s;

t – the time from the start of the flight of a particle or drop, p;

$\vec{g}$ – acceleration of gravity, m / s^2;

$\vec{W}$ – force of resistance of movement of particles or drops, N.

The equation of motion of the particles of dust and liquid droplets in the projections on the axis of coordinates is as follows:

$$\frac{du}{dt} = -g\sin\alpha_1 - \frac{6}{\rho\pi d_i^3} W_x;$$
$$\frac{d\upsilon}{dt} = -g\cos\alpha_1 - \frac{6}{\rho\pi d_i^3} W_y \qquad (2)$$

where u, υ – the projections of the velocity vector on the coordinate axis, m / s;

g – acceleration of gravity (assumed equal to 9.81m/s^2);

α_1 – working angle to the horizon, degrees;

ρ – the density of the particle or droplet (usually assumed equal to 1300 kg/m^3 – for coal dust particles and equal 1000 кг/м^3 – for wate);

d_i – diameter i – particles or drops, m;

W_x, W_y - projections of the vector of the force of motion resistance, N.

It is believed that the resistance forces of the body movement in the air are proportional to the kinetic energy of the relative motion and the area of the midsection of the body. In vector form, this dependency can be represented as follows:

$$\vec{W} = c_n \frac{\pi d_i^2}{4} \frac{\rho_0 |U| \vec{U}}{2}, \qquad (3)$$

where c_n – a drag coefficient that depends on the velocity and diameter of the particles or droplets;

ρ_0 – air density, kg/m^3.

For relative motion in the air flow, the formula (3) in the projections on the coordinate axis, taking into account the sign of the motion direction (on or against the flow) will take the form:

$$W_x = c_x \frac{\pi d_i^2}{4} \frac{\rho_0 |u \pm u_0| (u \pm u_0)}{2};$$
$$W_y = c_y \frac{\pi d_i^2}{4} \frac{\rho_0 |\upsilon| \upsilon}{2} \qquad (4)$$

where c_x, c_y – projection of the drag coefficient on the coordinate axis;

u_0 – ventilation flow velocity, m/s.

By substituting expression (4) into the system of equations (2), we obtain

$$\frac{du}{dt} = -g\sin\alpha - \frac{3\rho_0 c_x}{4\rho d_i}|u \pm u_0|(u \pm u_0);$$
$$\frac{d\upsilon}{dt} = -g\cos\alpha - \frac{3\rho_0 c_x}{4\rho d_i}|\upsilon|\upsilon \qquad (5)$$

The initial conditions are added to the equations of system (5) on the assumption that particles or droplets at the site of their formation acquire at an angle of inclination to the ground for production a velocity that does not coincide with the velocity of air:

$$1)u(0) = u_1\cos\alpha_2; \quad 2)\upsilon(0) = u_1\sin\alpha_2 \qquad (6)$$

where u_1 – initial velocity of dust particles or liquid droplets, m / s;

α_2 – the angle of inclination of the initial velocity of movement of particles or droplets to the production soil, degrees.

Numerous experimental studies show that the coefficient of resistance of a spherical shape obeys the two-term law and can be assumed to be sufficient

$$c_n = 0{,}5 + \frac{24\nu}{|U|d_i} \qquad (7)$$

The Fig. 4 shows the calculated curve (7) and the experimental data depending on the coefficient of resistance of motion of bodies of spherical shape from the local Reynolds number during the transition from laminar to turbulent mode.

The local Reynolds number is meant to the ratio of the dynamic forces of a particle of dust or a drop of liquid to the forces of air viscosity

$$, \mathrm{Re}_x = \frac{|u - u_0|d_i}{\nu}; \quad \mathrm{Re}_y = \frac{|\upsilon|d_i}{\nu} \qquad (8)$$

The maximal error of the calculated data, as shown by the comparison with the experimental data, does not exceed 10 – 20%. An analysis of the possible values of the local Reynolds number implies that it can vary widely. Therefore, taking the minimal diameter d_{min} = 1 μm and the minimal velocity u_{min} = 0.1 m / s, we obtain Re = 0.007. And taking the maximal diameter d_{max} = 1000 μm and the maximal velocity u_{max} = 100 m/s, we obtain Re = 6667.

Thus, the movement of dust particles and liquid droplets will shift from turbulent to laminar mode, capturing the transition mode. Therefore, considering only laminar mode using the Stokes law can lead to gross errors.

Solving second order algebraic equations (6, 7), we find the limit value of velocity projections

$$u_2 = \mp u_0 - \frac{2g\sin\alpha_1}{a_1 + \sqrt{a_1^2 + 4a_2 g\sin\alpha_1}};$$
$$\upsilon_2 = \frac{-2g\cos\alpha_1}{a_1 + \sqrt{a_1^2 + 4a_2 g\cos\alpha_1}} \qquad (9)$$

From the formula (9) it follows that at $a_2 = 0$ is the mode of motion is laminar and at $a_1 = 0$ – turbulent.

Figure 5 presents the dependence of the maximal vertical velocity on the diameter of the particles or droplets set by the second formula (9). The Fig. 5 turns out that using Stokes' law when assessing vertical velocity is possible only with a diameter of particles or droplets less than 200 microns.

It is actually hard to believe that a 0.5 mm diameter drop was moving at a speed of 7 m/s. Given the turbulence of the flow, its velocity will be according to the Fig. 5 only 2.5 m/s.

Moreover, it is impossible to use the Stokes law for longitudinal velocity in the active zone of the nozzle plume, where the local Reynolds numbers, as already noted, can be several thousand.

Findings. The mechanism of sedimentation of suspended carbon-containing dust on the working soil due to the action of gravitational and electrostatic forces has been clarified. It lies in the fact that as a result of the natural or forced charge of the dust cloud, its particles are attracted to the droplets of liquid, creating new nuclei, which, falling into the sphere of influence of electrostatic forces are deposited more effectively due to the fact that their mass is equal to the total mass of liquid droplets and particles of dust. As a result of theoretical and experimental studies using existing formulas it was developed a mathematical model of the dynamics of the interaction of dust and dispersed water flows interaction in gravitational and electrostatic fields.

Conclusion & Significance. Air pollutions have major impacts on human health, triggering, and inducing many diseases leading to high morbidities and mortalities. Atmospheric air protection is one of the most urgent problems in modern technological society, as scientific and technological progress and expansion of production is associated with an increase in negative anthropogenic impacts on the atmosphere. The paper presents a new solution to the current scientific problem of reducing carbon-containing dust content based on the disclosure of the laws of the aerodynamic interaction of dust and water flows in gravitational and electrostatic fields.

Based on the known theoretical and experimental

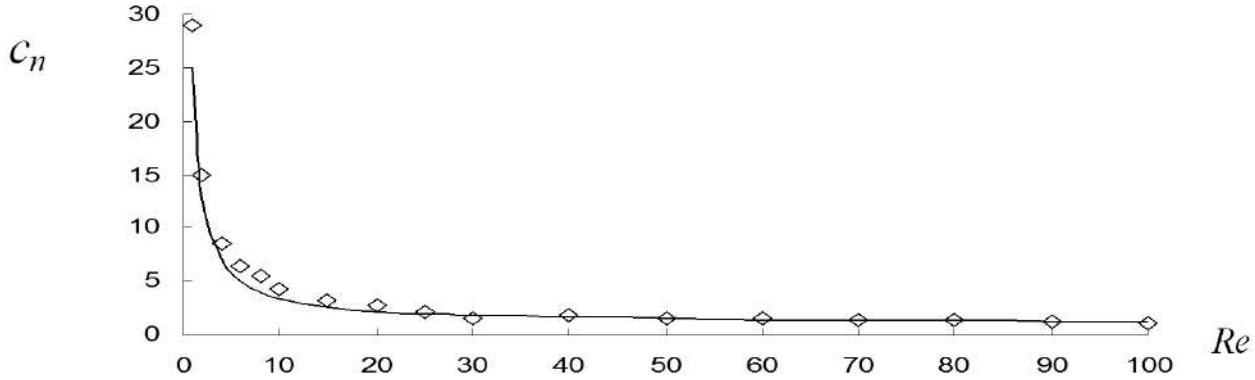

Fig. 4. Dependence of the coefficient of resistance of the motion of globular bodies on the local Reynolds number during the transition from laminar to turbulent mode

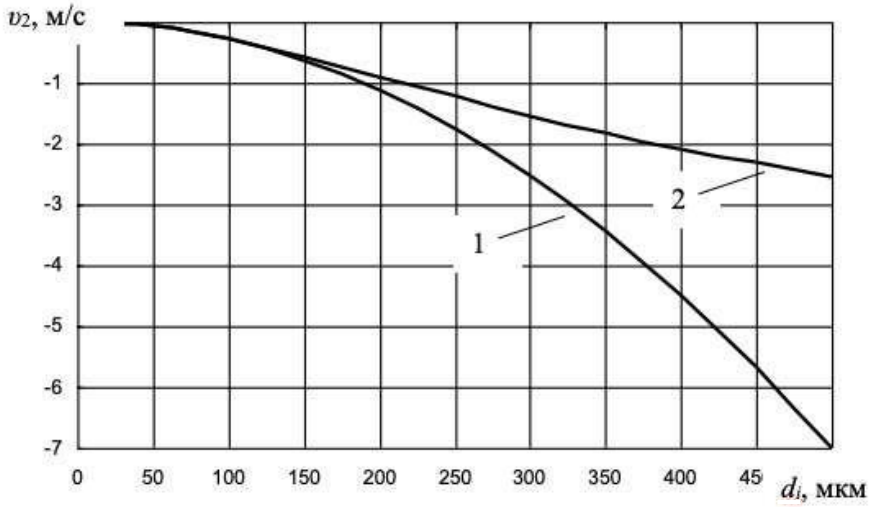

Fig. 5. Dependence of the maximal vertical velocity of a particle or droplet on its diameter during laminar (curve 1) and mixed (curve 2) modes.

data on the interaction of dispersed liquid with air-suspended dust, the mechanism for capturing suspended coal dust by fluid droplets in the ventilation stream has been clarified: dust particles do not have to be wetted and immersed in liquid droplets. This may not be in the case of natural and forced charge of dust and dispersed water flows. Having fallen into the sphere of influence of electrostatic forces, particles rush to drops until they fall on the soil of a mine working area, before they have time to coagulate. After particles of carbon-containing dust get onto the wet soil, the de-dusting effect of the ventilation flow will be achieved.

It has been proved that the movement of dust particles and droplets of fluid will pass from turbulent to laminar mode, capturing also the transition mode. Therefore, considering only laminar mode using Stokes law, as in the works of predecessors, can lead to gross errors. Studies have shown that using the Stokes law when estimating the vertical velocity of motion is only possible with particle or droplet diameters of less than 200 microns. Moreover, its not allowed to use the Stokes law for the longitudinal velocity in the active zone of the nozzle plume, where local Reynolds numbers can reach several thousand.

Technologies to reduce air pollution at the source of carbon-containing dust formation should be used in all new industries of economy. The results obtained reveal the mechanism of interaction of the sprayed liquid with coal dust and can be used in the development of new effective means of controlling the carbon-containing dust. The principles and practices of sustainable development, coupled with local research, will help to reduce or eliminate health and environmental risks resulting from air pollution by carbon-containing dust.

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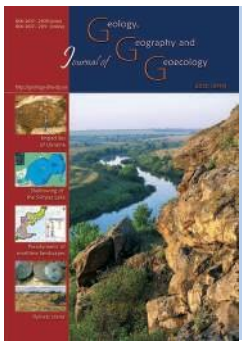

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Chornobyl Phenomenon: Catastrophe, Experimental Area vs Curiousity Object

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Abstract. The article is devoted to a qualitative thematic study of the Chernobyl phenomenon as a holistic phenomenon that combines a number of manifestations: from objects of direct visual perception to legends and myths about events, processes and Chernobyl in general. The integrity of the image of the Chornobyl zone makes the Exclusion Zone an attractive tourist destination, especially for those who is interested in gaining such experience. At the same time, using the method of thematic research and based on statistics, the Chernobyl phenomenon is considered in its real context and as a kind of indirect means to determine the level of interest of citizens of different countries in Ukraine (as a carrier of unique culture, history and world events). The results of the article are a contextual analysis of the phenomenon of Chernobyl as a tourist destination. Resource opportunities of nuclear tourism in the Chornobyl zone are analyzed. Methodological qualitative case study of the Chernobyl phenomenon includes accounting and description of tourist resources of Nature and resources of cultural identity of the cities of Pripyat, Chernobyl (with adjoining territories), which are cultural artifacts and are elements of the nuclear heritage of Ukraine, and can be included and presented in tourist routes. The contextual analysis of this study concerned the consideration and processing of data on the Chornobyl zone as a holistic phenomenon, from cartographic, textual documents, comparative analysis data of visitor loyalty, partial mathematical and statistical analysis of tourist attendance data. This case study is an approach to a comprehensive study of the phenomenon in the context of its actual existence using a variety of data sources. It is this comprehensiveness in the study of the phenomenon that ensures that the object is viewed from different angles, which allows you to reveal and understand all aspects of the phenomenon. The article reveals the main components of the Chernobyl phenomenon, mentions key tourist attractions that have their own history and shrouded in prophecies, legends and myths, as well as analyzes the tourist attendance of this destination by different categories of tourists, indicating significant interest in this territory.

***Keywords*:** *Chornobyl phenomenon, tourist attraction, destination, Chornobyl "image", exclusion zone*

Чорнобильський феномен: катастрофа, зона експерименту vs об'єкт підвищеної цікавості для допитливих

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Анотація. Стаття присвячена дослідженню Чорнобильського феномену як цілісного явища: від об'єкту безпосереднього сенсорного сприйняття до легенд та міфів про події, процеси та Чорнобиль загалом. Цілісність образу Чорнобильської зони робить територію відчуження привабливою туристичною дестинацією, особливо для тих, хто зацікавлений у отриманні досвіду атомного туризму. Водночас, використовуючи метод тематичного дослідження та ґрунтуючись на статистиці, явище Чорнобиль розглядається в його реальному контексті та як своєрідний засіб для визначення рівня зацікавленості громадян різних країн в Україні (як носія унікальної культури, історії, свідка світових подій). Результати статті – це контекстний аналіз феномену Чорнобиля як туристичного напрямку. Проаналізовано ресурсні можливості ядерного туризму в Чорнобильській зоні. Методологічно контекстуальне вивчення явища Чорнобиля включає облік та опис туристичних природних ресурсів та ресурсів історико-культурної спадщини міст Прип'ять, Чорнобиль (з прилеглими територіями), які є історико-культурними артефактами та елементами ядерної спадщини України і можуть бути включені та представлені в туристичних маршрутах. Це тематичне дослідження є підходом до всебічного вивчення явища в контексті його фактичного існування з використанням різноманітних джерел даних. Контекстуальний аналіз в дослідженні стосувався розгляду та обробки даних про Чорнобильську зону як цілісне явище з картографічних, текстових документів, даних порівняльного аналізу лояльності відвідувачів, частково-го математичного та статистичного аналізу даних відвідуваності туристів. Саме ця всебічність у дослідженні явища забезпечує

розгляд об'єкта з різних сторін, що дозволяє розкрити та зрозуміти всі аспекти явища. У статті розкриваються основні складові явища Чорнобиля, згадуються ключові туристичні визначні пам'ятки, які мають власну історію та оповиті пророцтвами, легендами та міфами, а також аналізується відвідуваність цього місця різними категоріями туристів, що свідчить про значний інтерес до цієї території.

Ключові слова: *Чорнобильський феномен, туристична привабливість, дестинація, «образ» Чорнобиля, зона відчуження*

Introduction. Life experience shows that something big is noticed from a distance. The Chernobyl phenomenon, which was manifested by a striking and actually well-known Chernobyl disaster in April 1986, is a landmark event of the late 20th century on a global scale. At the same time, the scale of the catastrophe received quite a good losses estimation within the first few years after the disaster happened.

But the Chornobyl phenomenon remains currently little studied and, moreover, judged by its influence on the mankind existence, including the noosphere, and the global ecosystem as a whole. Obviously, the scale of the phenomenon mentioned is so large that it can only be more or less properly grasped the decades later. In addition to the catastrophe itself, accompanied by the pure statistics only, the Chornobyl phenomenon combines the information content filled with various myths, legends, testimonies and considerations; system of established and at the same time little-researched causes of the catastrophe; a system of consequences that make themselves known over time. Therefore, it is the Chornobyl phenomenon, rather than the catastrophe itself, that is of much greater interest for not only the narrow-specialized professionals and civil servants). The tourists, at least the vast majority of them, are more likely attracted to the "Chornobyl image" formed on the basis of the above-mentioned components of the Chornobyl phenomenon than the catastrophe itself. One can only discover that the decorative image of Chernobyl, widespread in Ukraine and even in the world, is at least clearly simplified, and most likely sufficiently distorted. As a result, a number of grounds are being formed to distort the general idea of the Chornobyl phenomenon and thus the Chornobyl disaster and its actual, rather contradictory consequences. In the context of this article that may cause the local and foreign tourists' disappointment, generated by "the expected" and "the experienced" mismatch after visiting the Chernobyl zone. Therefore, in order to prevent the undesirable effects generated by distortions of the Chornobyl phenomenon, there is a need to comprehend the mentioned phenomenon systematically relying on the analysis of various statistics, available information base, etc.

Nuclear artefacts around the world are becoming increasingly popular tourist attractions. Tourists make new sense of recreation traveling to such places. Such journeys are an immersion in existing realities through a review of a period of world history that has fundamentally changed the world. Such vacations are one way of understanding the history of the nuclear era. Visiting nuclear weapons test sites, holding innovative nuclear energy research, exhibitions in museums focused on the history of nuclear development and demonstrating the arms race legacy and the Cold War, nuclear accident sites are the interests of a particular nuclear tourism. Nuclear tourism has been separated from dark tourism due to the conceptual approach to the motives of visiting such places (Ropeik, 2012; Gauldie, 2019; Lennon, Foley, 2000; Brand, Platter, 2011). The dark tourism culture, above all, shows such destinations as nuclear wastelands as a demonstration of the atomic bombs mighty power. In the practice of dark tourism, the destructive force of the nuclear explosion is called the Eiffel Tower of the dark tourism. For example, in Japan, this tendency is of concern. Since for the most part tourists visiting the damaged artefacts of Nagasaki and Hiroshima are not looking for a humanitarian sense in the impact of nuclear weapons or energy at all, and are only looking for bright selfies in the ruins of the former cities of Hiroshima and Nagasaki (Italie, 2011; Schäfer, 2016; Gauldie, 2019). However, there is still an urgent need to shift the accents to the space of humanizing phenomena with a tragic atomic history. In accordance with the humanistic approaches used by atomic tourism, the attractions of nuclear travel are demonstrated with some enlightenment to the public about not only the positive impact of nuclear energy. But also highlights the negative effects of using nuclear energy (Lennon, Foley, 2000; Brand, Platter, 2011; Gerster, 2013; Stone, Hartmann, Seaton, Sharpley, White, 2017). Many sites of atomic tragedies are confronted with ethical issues of combining compassionate understanding with the destructive history of atom.

However, visiting of nuclear power plants have the potential to improve people's energy literacy, improve understanding of how we consume energy, raise awareness of nuclear waste storage, or the potential impact of nuclear activity on the local economy. With regard to nuclear power plants, a certain content of knowledge and experience may be exposed here: history and construction of power plants; principles and technologies for the production of nuclear energy

and related issues such as nuclear safety and security; topics related to the disposal of radioactive waste; environmental and landscape impacts (Goatcher and Brunsden, 2011; Pasqualetti, 2012; Yankovska та Hannam, 2014; Stone, Hartmann, Seaton, Sharpley, White, 2017; Beer, Rybar, Kalavsky, 2017; Frantal, Urbankova, 2017, Boyle, 2017).

Recently, quite a number of researchers are addressing the issues of nuclear tourism in the world. However, not only tourism scientists or naturalists, but also journalists and bloggers, should be mentioned among interested researchers. Independent journalist investigations and research of the problematic ethic issues of visiting sites with nuclear history are quite interesting experimental data. In a number of studies, considerable attention is given to the role of artefacts of military nuclear tourism in the public awareness of important historical events and periods, and at the same time, nuclear discourse has an important influence on the formation of national identity. An example of the coverage of events in the history of interstate relations and the formation of humanistic consciousness in nuclear policy are the work of authors who analyse the role of the Manhattan Project and see it as an American nation-building project that began after World War II, lasted during the Cold War and was developed in the aftermath of the Cold War (Berger, 2006; Coolidge, Simons; Rugoff, 2006; Gerster, 2013; Gauldie, 2019; Osofsky LuLing, MacFarlane, 2019).

The Department of Energy (DOE) is responsible for preserving the historical heritage of nuclear artefacts and, in particular, the Manhattan Project and promoting nuclear tourism in the United States. DOE support the Nuclear Age monuments and the popularisation of nuclear tourism, the activities of the Atomic Heritage Foundation (AHF). The activities of AHF and DOE in the US emphasize the relationship between the popularisation of nuclear power, the benefits of nuclear energy and the complexity and controversy of the atomic power studies legacy in America (websites: Atomic Heritage Foundation and US Department of Energy). However, nowadays, discussions are balanced between assessing the constructive power of nuclear energy and recognizing its destructive past and potential.

There are a lot of publications dedicated to the question development of the educational impact of nuclear tourism as part of environmental science and STEM-education, the creation of such forms of tourism that would combine environmental education, the presentation of new technologies and interactive research experiments and various outdoor activities focused on families or thrill seekers, for instance, works of Gerster, 2013; Frantal and Urbankova, 2017; Beer, Rybar, and Kalavsky, 2017; Mazeikiene and Gerulaitiene, 2018. For instance, publications on the websites of AHF, DOE and UNESCO, etc.

The questions are not of the ethics of nuclear tourism only, but also the topics of developing opportunities for territorial communities based on the maintenance of museums of nuclear artefacts, tourist atomic attractions and the support of educational routes were raised and revealed in the works of Frantal and Urbankova, 2017; Beer, Rybar, and Kalavsky, 2017; Mazeikiene and Gerulaitiene, 2018. Thus, the highlighted work on the EDUATOM project by the authors, Mazeikiene and Gerulaitiene, 2018, is a scientifically grounded educational route for nuclear tourism near the Ignalina NPP area. The publication shows the parameters and elements of the atomic heritage of the territory, which act as cultural artefacts and may be included and presented in tourist routes as an extension of the economic opportunities of the local community.

The ethics of organizing nuclear tours and visiting nuclear sites, museum expositions about nuclear tragedies, exploring individual destinations and attractions of nuclear tourism are discussed not only by scientists: notably by Coolidge, Simons, and Rugoff, 2006; Osofsky and MacFarlane, 2019; Yankovska and Hannam, 2014; Goatcher and Brunsden, 2011; Beer, Rybar, and Kalavsky, 2017; Schäfer, 2016, etc. But also by independent journalists such as: Morris, 2014; Gauldie, 2014; Ropeik, 2012; Bliss, 2014, Boyle, 2017; Italie, 2018, etc.

From the point of view of the study of tourist behaviour and the formation of established images of nuclear accident sites, the works of Morris, 2014; Gauldie 2014; Bliss, 2014; Boyle, 2017; Italie, 2018 are very interesting. For example, Morris H. (2014) presents the results of studying of systematic teenager's expeditions to the Chornobyl zone to obtain purely extreme sensations, and this is, in fact, a deep anthropological study of the behaviour of extremal tourists and, in general, the attitude of a certain part of the population to Nuclear Age artefacts. The research of the heritage of nuclear tours that took place in the 1950s in the United States (New Mexico, Las Vegas) and the so-called "atomic boom" caused by atomic weapons tests also allow us to understand and classify the motives behind tourists and average citizen recreation or entertainment shows presented by Bliss, 2014; Boyle, 2017. Experience of visiting nuclear sites in Japan, including not only Hiroshima and Nagasaki but also Fukushima. Description of Japan's experience in overcoming a humanitarian crisis from a power plant

bombing and environmental disaster described by Frantal and Urbankova, 2017; Schäfer, 2016; Gauldie, 2014; Italie, 2018; Beer, Rybar and Kalavsky, 2017. Also presented at the websites of organizations: such as UNESCO, the US Atomic Heritage Foundation, and the US Department of Energy.

Meanwhile, everything related to the Chernobyl disaster has certainly been investigated in detail in several tangential planes. Firstly, it is about national security. Every powerful country, which has at least nuclear power, has, through the forces of the respective institutions and institutions, conducted systematic research on a range of issues related to the protection of their societies, both from similar disasters and from the probable identified and acceptable consequences of such disasters. As for the probable causes of the Chernobyl accident, as well as the actions and orders of the state bodies related to the accident liquidation and its consequences, it is worth mentioning the most recent edition in the world. This is the edition "KGB Chornobyl file. Public sentiment. Chernobyl in the post-catastrophe period". It was worked out by a large group of experts to make available the large part of the documents and testimonies contents of 1986-1991 to the public. The documents reveal the features of post-Chernobyl life. Among other things, the book also reflects the world community representatives' reaction to the Chornobyl tragedy.

Secondly, it is about public opinion. The civil society of the least developed states, first and foremost by the forces of the so-called fourth power (that is the mass media) has explored the impact of the catastrophe and its consequences on the very public opinion and the informational and emotional atmosphere in the society. Undoubtedly, the classical science has been involved in the study of the objective factors related to the catastrophe. The results of the Chernobyl disaster comprehensive studies have been delivered in numerous scientific articles and monographs. At the same time, as the academician mentioned in his report, "In recent years, the scientific support for works in the Exclusion Zone has been carried out mainly by employees of the institutions subordinated to the Exclusion Zone Management State Agency of Ukraine (EZSA) and organizations involved in the administration of the Chornobyl NPP. As for the academic institutions, only the Institute of Nuclear Power Plant Safety Problems of NAS of Ukraine constantly worked in the area" (Lisichenko, 2016: 8).

As for the tourist attractiveness of the Chernobyl zone and everything related to it, scientific and scientific-journalistic investigations are also represented quite widely by both local and foreign researchers. Among the journalists conducting systematic investigations of the Chornobyl phenomenon from the tourist attractiveness point of view, Oles Dashchynsky, Sergey Mirny, Yevhen Solonin, Stanislav Yurchenko have a prominent place in particular. The systematic tourist routes reviews, the advantages of various sites of tourist interest in the territory of the Chernobyl Exclusion Zone have been reflected in their numerous publications. In turn, the scientific analysis of the Chernobyl tourist destination features is reflected in the articles of a number of experts in the field of geography and tourism, i.e. Pestushka V. Yu., Chubuka Yu. P., Solonina E.A., Yurchenko S.I. and others. As for the foreign scientists, Beresford N.A., Scott E.M., Copplestone D. have devoted considerable attention to the research of the Chernobyl problem. They focused the attention on the analysis of the radiation effects on the plant and animal world in the exclusion zone. Shkaruba A., Skryhan N. consider the state policy of Belarus against the Chornobyl zone, including its tourist attraction.

Materials and methods of research. Meanwhile, having a considerable amount of information about Chornobyl in the context of a wide range of problems, the Chornobyl phenomenon remains poorly understood at the moment. At least, the integrated vision of Chornobyl as sources of the complex knowledge acquired through experience is almost not formed. The Chernobyl accident and everything related to it, staying at the Chernobyl zone, the feedback, the impressions and the reflections on Chornobyl of those who have visited or otherwise explored the Chornobyl phenomenon are not taken into account properly. Therefore, there is a need for further investigation of the Chornobyl phenomenon as a unique phenomenon in the life of modern mankind, as an example of probable directions of further evolution in the context of the total technologization of the human existence.

The results of the article are a contextual analysis of the phenomenon of Chernobyl as a tourist destination. Resource opportunities of nuclear tourism in the Chornobyl zone are analyzed.

Contextual analysis is an important research approach to qualitative case study methodology to finding out the uniqueness of the Chornobyl phenomenon as a tourist destination (Baxter, Jack, 2008). Methodological qualitative case study of the Chernobyl phenomenon includes accounting and description of tourist resources of Nature and resources of cultural identity of the cities of Pripyat, Chernobyl (with adjoining territories), which are cultural artifacts and are elements of the nuclear heritage of Ukraine, and can be included and presented in tourist routes.

The contextual analysis of this study concerned the consideration and processing of data on the Chornobyl zone as a holistic phenomenon, from cartographic, textual documents, comparative analysis data of visitor loyalty, partial mathematical and statistical analysis of tourist attendance data. This case study is an approach to a comprehensive study of the phenomenon in the context of its actual existence using a variety of data sources. It is this comprehensiveness in the study of the phenomenon that ensures that the object is viewed from different angles, which allows you to reveal and understand all aspects of the phenomenon.

Results and analysis. Prior to the events of April 1986, Chernobyl, as a place of the NPP location, was no different in any of the sections of human activity, including tourist destination. After the catastrophe, which has led to numerous uncovered and unidentified consequences, at least so far, Chornobyl takes rather different image both in the minds of individuals and at the level of public opinion. It is becoming a subject of scrutiny, as well as a kind of business card of Ukraine in the world community. Since the catastrophe, the Chornobyl phenomenon appears in the life of mankind – a unique phenomenon, which, by the way, is rich in mythology, prehistory, unfolding events and a spectrum of accompanying and explanatory information. Thus, among other things, Chernobyl acquires first in potency and then in reality, the status of a unique tourist destination. At least, the image of Chernobyl is clearly identified by anyone interested in catastrophes, their consequences or anything related. At the same time, the Chornobyl phenomenon proves to be a unique, moreover, if not the only one source of specific experiences generated by a combination of heard, seen, perceived and understood.

So, if we approach the Chornobyl phenomenon structurally, mainly as a tourist destination, its components include:

- 30 km exclusion zone with some exceptions;
- summarizing all kinds of official and/ or background information about the territory, settlements, Chernobyl and other objects, environment, flora and fauna and, accordingly, their initial (before the accident) and current status;
- the results of scientific research on the effects of radioactive radiation on flora and fauna representatives, as well as on humans;
- declassified materials, in particular those that recently came to light in the Chernobyl disaster collection “KGB Chornobyl File. Public sentiment. Chernobyl in the post-catastrophe period”;
- a set of alternative information in the form of retellings, legends, including prophecies, including those related to the Apocalypse of John, myths, private considerations and assumptions about facts and events, one way or another related to the Chornobyl phenomenon;
- statistics in terms of attendance of the Chernobyl tourist destination.
- Obviously, the objects of high interest among tourists, which are in the 30 km zone and have their own history, including myths and legends that give the object a peculiar halo of secrecy, should include:
- deactivated- the so-called Red Forest – a former pine forest, which was exposed to the most powerful radioactive exposure due to the explosion at the 4th unit;
- Chernobyl NPP, including sarcophagus - protective shelter over 4 power units, model room in the APC-1 of the ChNPP, block reactor control panel (BSU), “Golden Corridor”, machine room (turbine), reactor shop, room with DHW (main circulation pumps)), ChNPP cooler pond, unfinished ChNPP third stage cooling tower; the construction site of the new confinement “Ark”, which is the next step in the international SIP project implementation aimed at transforming the object “Shelter” into an environmentally sound system, a memorial near the administrative building;
- abandoned experimental animal radiobiology base;
- the city of Pripyat, including the kindergarten, the school, the city executive committee (where the first headquarters of the accident consequences elimination was organized), the Polissya Hotel (on the basis of which the observation point for helicopter operations over the ruin of the 4th reactor was organized), the hospital (where the first victims of the accident and its elimination were taken into), the police reference point and the detention center, as well as the city pool of the Pripyat River with the marina and the flooded pier, the attraction “Ferris Wheel”;
- the city of Chornobyl, including the city’s interior, an exhibition of robots and equipment involved in the Chernobyl disaster elimination, as well as the Chornobyl castle of the 17th – 18th centuries, the ancient cemetery, a Dominican monastery of the 17th century and the archaeological excavations;
- other settlements in the 30 km exclusion zone, including the villages of Zamoshnya and Bychki, on the territory of which there are remains of Old Believers churches and cemeteries; Rudnya-Veresnya – the place of ancient production of iron from marsh ore; Paryshiv, where self-settlers live – people who have returned illegally in the 30 km zone

for further permanent residence, and others. Often the well-preserved comfortable buildings of the mid-nineteenth and early twentieth centuries add further interest to the villages;

- Yaniv Station, a park of abandoned trains and locomotives, a ritual cross-figure at a crossroads, a historic pine tree in the form of a trident, transferred from the so-called Red Forest;

- the functioning Chornoby St. Nicholas Convent;

- "Chornobyl 2" military object is an arc radar station "Doug 3" (index: 5H32). Built and launched in 1976, a Soviet radar station for the early detection of launches of intercontinental ballistic missiles. It was named "Woodpecker "for its specific sound effect. In NATO reporting documents it was referred to under the name "Still Yard;

- natural landscapes, including the location of the confluence of the Braginka River in Pripyat; the former ferry crossing the Pripyat River, the Dnieper River and historic Chernobyl views its with traditional buildings and houses, the Paryshivska and Yanivsky bridges;

of routes and find the information about them on the official website State Agency of Ukraine on Exclusion Zone Management (Official website of State Agency of Ukraine on Exclusion Zone Management) exclusion as that is attached below.

Therefore, the Chornobyl Zone is interesting not only for the Ukrainian citizens, but also for the tourists from other countries. In addition, it should be noted that on 01.01.2019, the citizens from 119 countries (out of 195 world states) have visited the Chernobyl zone within the last 9 years. That has been proved by a number of statistics. In particular, referring to the data in Table 1, it can be noticed that during these years there was a constant increase in both the number of tourists and the geography of visitors.

Naturally, the largest group of tourists in the Chernobyl Exclusion Zone are Ukrainians. In particular, 21,949 citizens of Ukraine showed an interest in direct acquaintance with the tourist destination mentioned above, which is 0.49 × 10-3% as a percentage of the total population in 2018. Among

Table 1. The number of visitors to the Exclusion Zone from 2011 to 2018

Year	Number of Delegations	Number of Visitors		Countries
		Total	Foreigners	
2011	740	9127	6423	76
2012	1467	14132	10115	88
2013	1516	17757	13740	76
2014	1063	8404	5055	69
2015	1642	16386	10485	84
2016	2857	36781	24492	93
2017	3520	49758	34838	114
2018		71862	49811	119

- Chornobyl Radiation-Ecological Biosphere Reserve. "According to the scientists, there may be more than 400 species of animals, birds and fishes, including those ones in the Red Books. So far, 300 species have already been identified, 19 of which are listed in the Red Book of Ukraine. Also, 1,228 species of higher plants have been identified, 61 species of which are rare and are subject to conservation" (Official Site of the Reserve).

At the same time, there are a number of one- and two-day motor transport or walking tours. More recently, air (helicopter) and water (motor boat) tours are being offered. Leisure activities in the exclusion zone are organized by licensed tour operators, including "The Chornobyl Tour" (Official website of «The Chornobyl Tour»). Information support is available in several languages, depending on the wishes of tourists.

Accordingly, those interested in travelling to the Chornobyl Exclusion Zone can choose a variety

other things, the latter may indicate the relatively low cognitive, and even more obviously, recreational appeal of the exclusion zone to the local population. Accordingly, there is a need to study the level and quality of the Ukrainian population awareness about the Chernobyl destination along with the motivational sphere of those who have expressed a desire to visit Chernobyl.

Last year, the largest number of the foreign tourists' flows to the Chernobyl zone were the British – 6164 and the Poles – 5314 people respectively. However, considering the number of tourists to the population of the country, Lithuanians – 433 × 10-6%, Czechs – 289,7 × 10-6% and Finns – 232 × 10-6% respectively showed the most interest in Chernobyl. While the lowest interest among the countries where the tourism industry is relatively well developed showed the Chinese – 0.45 × 10-6% and the Russians – 0.66 × 10-6%. The corresponding results are shown in Table 2.

Referring to the indicators in Table 2, and bearing in mind that the Chornobyl phenomenon is actually both a world unique phenomenon and a unique tourist destination, it is possible to draw some conclusions about the level of Ukraine position in the world, i.e. the loyalty or curiosity of citizens of foreign countries to Ukraine. In particular, Lithuanians, Czechs and Poles show the greatest loyalty to Ukrainians in the mentioned context, which, by the way, more or less corresponds to the results of direct measurements of the political liking of both the population and the political leaders of the countries mentioned above. At the same time, both the Chinese citizens and the political leaders are the least interested in Chernobyl and indirectly in Ukraine. Naturally, a noticeable distance compared to, for example, the Lithuanians, Poles or Czechs, who are actually our neighbors, could justify the Chinese indifference to Ukraine. But comparing to interest of the Ecuadorian and the Japanese who have more or less the same the Fukushima phenomenon at hand, the inertia of the Chinese towards Ukraine becomes evident.

On the other hand, despite the high involvement of the Russians in the socio-political life of Ukraine which is purposefully stimulated by the central authorities through various instruments including the media, the Russians shows a very low interest in the real sources of information about Ukraine and to the Chornobyl tourist destination. The latter allows to make a number of conclusions. In particular, in a period of the information war, tourism is a very effective means of counteracting the results of the war, since it allows "the victims" of information battles to open their eyes to the true state of affairs in many ways. So, we can make a rather pretentious assumption based on this conclusion: the more a person is inclined to make meaningful journeys aimed not only at rest, but at the outlook extension the less he is subjected to manipulative influences on his outlook and his attitude to certain problems and issues. Therefore, every totalitarian system naturally must gravitate towards total control of the tourist sphere and the tourist demands of its citizens. A striking example is the former Soviet Union, a modern North Korea, as well as the many countries of Africa and Asia where citizens are under the strong control of a state and/or tradition, such as Islamic ones. Conversely, countries that are actively developing a democratic system and atmosphere of social comfort for their citizens are characterized by high levels of tourist demand of, so to say, a developing nature.

Table 2. A sample of countries represented by a significant number of citizens who visited Chornobyl in 2018 according to the number of tourists to the population of the country ratio

Countries	Number of Tourists: people	Number of population: mln. people.	Number of tourists to number of population ratio
Australia	1194	24,6	$48{,}5 \times 10^{-6}$ %
Great Britain	6164	66,04	90×10^{-6} %
Ecuador	124	16,62	$7{,}5 \times 10^{-6}$ %
Canada	1057	37,06	28×10^{-6} %
China	641	1386	$0{,}45 \times 10^{-6}$ %
Lithuania	1233	2,848	433×10^{-6} %
Netherlands	2413	17,08	141×10^{-6} %
Germany	4558	82,79	55×10^{-6} %
Poland	5314	38,43	138×10^{-6} %
Russia	96	144,5	$0{,}66 \times 10^{-6}$ %
Slovakia	1429	5,435	$26{,}3 \times 10^{-6}$ %
USA	3804	327,2	$11{,}6 \times 10^{-6}$ %
Finland	1277	5,503	232×10^{-6} %
France	1504	66,99	$22{,}6 \times 10^{-6}$ %
Czech Republik	3065	10,58	$289{,}7 \times 10^{-6}$ %
Sweden	1913	9,995	$191{,}4 \times 10^{-6}$ %
Japan	555	126,8	$4{,}4 \times 10^{-6}$ %
Ukraine	21949	44,83	489.6×10^{-6} %

Conclusions. Each country has its own so-called business cards. It happened that Ukraine is known in the world not least due to the Chernobyl tragedy. Therefore, among other things, the Chernobyl Exclusion Zone has become a tourist destination, and on the other hand, the image of Ukraine contains the Chornobyl phenomenon. This is, in fact, a unique phenomenon on a global scale which clearly demonstrates an alternative variant of existence being exposed to radiation due to an accident at an atomic object. In addition, the Chornobyl phenomenon is

the source of the full range of information from the visual to the audio and the experiences generated by the symbiosis of what has been seen, heard, and made sense. Thus, with a wise approach of state institutions and people responsible for the Chernobyl phenomenon, the latter can be used to increase the level of Ukraine recognition and its tourist attractiveness in the world. At the same time, in case of the state and business circles efficient interaction, the Chornobyl phenomenon can also become one of the most interesting objects in the context of event tourism, since on the one hand it has all the necessary resources and on the other «… in the world there is a certain process of refocusing the overwhelming majority of wealthy countries' citizens from business-related values to the values associated with pleasure from various educational and moderately extreme entertainments. Thus, event tourism and entertainments, special events respectively gain tangible importance and significance on the one hand as a desirable and as an integral element of the life of a civilized world secured representative. On the other hand, it is a business activity" (Kaluha, 2018: 89).

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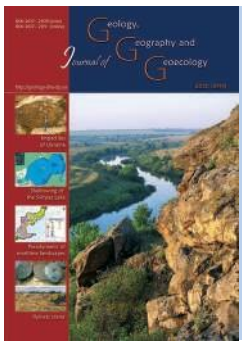

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Geographical peculiarities of the mortality risk of the population of Sumy region from cardiovascular diseases

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Abstract. Cardiovascular diseases (CVDs) are the main group of diseases from which the population of Sumy region suffers. They have not only high rates of primary morbidity and prevalence, but also play the leading role among the causes of mortality in the region. The aim of the article is clarification of the geographical features of mortality of the population of Sumy region from diseases of the circulatory system. In 2018 compared to 2012 the mortality of the general population in Sumy region from this class of nosology decreased by 1.17%, although among the able-bodied population it grew by 1.94%. The geographical differences of mortality (including separately the group of able-bodied population) from various CVDs: coronary heart disease, acute myocardial infarction, cerebrovascular disease, cerebral strokes and strokes with hypertension, were established. For determining the regional features of mortality of the population from cardiovascular diseases we used the integrated indicator «disease mortality risk assessment». This indicator takes into account the relationship between the primary morbidity, prevalence of diseases and the causes of mortality and makes it possible to assess the state of health of the population in terms of CVDs. It was found that the inhabitants of Sumy, Romny, Nedryhailiv, Putyvl' and Lypova Dolyna districts, where the highest integrated indicator value was observed , have a high risk of dying from diseases of the cardiovascular system,. At the same time for the city of Sumy, Bilopillia and Krasnopillia districts, a low level of the mortality risk from CVDs is characteristic. Among the able-bodied population of Sumy region, the inhabitants of Seredyna-Buda and Yampil' districts are at the highest risk of mortality from CVDs. A forecast of the mortality of the population of Sumy region before 2023 was made. The baseline scenario showed a decrease of mortality from CVDs by 2.1 %. From the optimistic forecast (lower 95% confidence bound) the mortality rate from CVDs for 2023 will fall by 19.4%, while the pessimistic forecast (upper 95% confidence bound) shows an increase in the mortality rate by 13.3 %. As a result of ranking the values of the integrated indicator of mortality from cardiovascular diseases, it was found that in the first place is the risk of dying from a stroke, in the second place – from cerebrovascular diseases, and in third place – from strokes with hypertension. Next are the risks of dying from coronary heart disease and myocardial infarction. The results of the study can be used by local authorities to prevent the growth of morbidity and mortality from diseases of this nosological class, as well as for development of preventive measures and stabilization of the health status of the population of Sumy region.

Key words: cardiovascular diseases, mortality, primary morbidity, prevalence of diseases, morbidity factors, Sumy region

Географічні особливості ризику смертності населення Сумської області від серцево-судинних захворювань

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Анотація. Стаття присвячена розгляду географічних особливостей смертності населення Сумської області, зумовленої серцево-судинними захворюваннями (ССЗ). Отримані результати ґрунтуються на даних щорічних статистичних звітів медичних установ Сумської області, які підпорядковуються Міністерству охорони здоров'я України. Спостереженням охоплено період 2012–2018 рр. Встановлено географічні відмінності смертності населення (у т.ч. окремо серед населення працездатного віку) від різних ССЗ: ішемічної хвороби серця, гострого інфаркту міокарда, цереброваскулярних хвороб, мозкових інсультів та інсультів з гіпертонічною хворобою. Для визначення географічних особливостей смертності населення від даної групи патологій було використано комплексний індикатор «оцінка смертності у результаті захворювання». Цей показник враховує співвідношення первинної захворюваності, поширеності ССЗ та спричиненої ними смертності й дає можливість оцінити стан серцево-судинного здоров'я населення. Встановлено, що найвищий ризик померти від хвороб системи кровообігу мають жителі

Сумського, Роменського, Недригайлівського, Путивльського та Липоводолинського районів, де спостерігаються найвищі значення названого вище комплексного показника. У той же час для мешканців м. Суми, Білопільського та Краснопільського районів ймовірність померти від цієї групи нозологій нижча. Серед вікової групи працездатного населення області найвищі ризики смертності від ССЗ мають жителі Середино-Будського та Ямпільського районів. Для передбачення рівня смертності населення Сумської області від ССЗ, було розроблено прогноз до 2023 р., який показав зниження рівня смертності жителів від хвороб системи кровообігу на 2,1 % за базовим сценарієм. Разом з тим, межі 95% довірчого інтервалу прогнозного показника смертності населення від хвороб системи кровообігу до 2023 р. допускають як скорочення рівня смертності на 19,4 %, так і її зростання на 13,3 %). У результаті ранжування отриманих значень комплексного індикатора смертності населення від ССЗ встановлено, що на першому місці за ризиком спричинити смерть знаходиться мозкові інсульти, на другому місці – цереброваскулярні хвороби, і на третьому місці – інсульти з гіпертонічною хворобою. Далі розташувалися ризики смертності від ішемічної хвороби серця та інфаркту міокарда. Результати оцінки географічних особливостей смертності населення області від ССЗ можуть бути використані місцевими органами управління для запобіганню зростання рівня захворюваності та смертності населення від хвороб даного нозологічного класу, для розробки профілактичних заходів і стабілізації стану здоров'я населення Сумської області.

Ключові слова: серцево-судинні захворювання, смертність, первинна захворюваність, поширеність захворювань, фактори захворюваності, Сумська область

Introduction. The mortality rate is one of the criteria for assessing the health status of populations. Cardiovascular diseases (CVDs) are among the main causes of mortality .This nosology class is the leader by most indicators of population health – primary morbidity, prevalence of diseases, mortality as well as temporary disablement and disability. Many CVDs are diagnosed in an advanced state, therefore they are difficult to cure, which quite often leads to mortality. WHO estimates (Global, 2017) that the most significant cause of deaths globally was CVDs. So, in 2016 from this category of disease 17.9 million people died (31% of all deaths in the world). Most (85 %) of these deaths were the result of heart attack and stroke. WHO projected (Cardiovascular, 2017) that in 2030 23.6 million will die from CVDs, primarily from heart diseases heart and stroke. These diseases are leading causes of death globally (Cardiovascular, 2017). Compared to other European countries, the mortality of the population in Ukraine from CVDs is higher. E.g., compared to Poland it is twice as high, three times more than in Greece, four times higher than in Germany, and six times higher than France (Kovalenko, 2013). Also, it is worth saying that in most countries of Europe mortality from CVDs is tending to decrease, for example (Almendra, 2020) during 1991-2017 the level of mortality from CVDs in Portugal decreased by 33.3 % (from 468.1 cases of mortality per 100 000 people to 312.4 cases per 100 000).

During 1991-2013 in Ukraine the morbidity of the population from CVDs grew twofold and the prevalence of diseases – three times. The level of mortality of the population of Ukraine from CVDs doubled (6 out of 10 deaths are caused by CVDs). Therefore, CVDs are the unchallenged leaders in the structure of causes of death of the population (Smertnist, 2016). Annually from these pathologies about 160 thousand people die, which is more than all other causes of death together (cancer, tuberculosis, AIDS, etc.) (Kornus, 2015; Rosul, 2015; Sertsevo-sudynni, 2018). Back in the 1960s CVDs were recognized as an epidemic, named «silent killer», this was especially true for coronary heart disease and hypertension (Kulchytska, 2001). As noted in the monograph by E. Libanova (Libanova, 2007), deaths from CVDs in Ukraine occur much earlier than in highly developed countries. This is a consequence of the lack of tradition of preventive health examinations, irresponsible attitude to the life of majority of the population, poor health system, among others. Moreover, as a result of CVDs in Ukraine annually more than 14-15 people per 100 000 inhabitants become invalid.

Mortality is not only a demographic indicator, but also an informative indicator of the population's health, as well as an indicator of socio-economic development. Therefore, study of the level of the mortality of the population, in our case from CVDs, provides an opportunity to evaluate the functioning of the health care system of both the country and individual regions. The relevance of the study is emphasized by the high rates of the mortality from CVDs. The negative upward trend of incidence of CVDs in the population and the high rate of death from them requires comprehensive research not only by medical professionals, but also by geographers, economists, sociologists, ecologists, etc.

Review of previous research indicates that significant attention has been paid by scientists of different profile (medicine, geography, economics, ecology, etc.) to this subject. Regional differences of the Ukrainian's population morbidity by various diseases, including CVDs, were considered in the works of various geographers. However, there are few works aimed at a socio-geographical study of mortality of the population from CVDs on the regional level and they are mainly aimed at analyzing the morbidity rate of the population. Thus, the work by I. Horbas (Horbas, 2010) shows the results of a 30-year study of

the epidemiological situation with CVDs in Ukraine.

In I. Horbas's research the high prevalence of the cardiovascular risk factors was established and a forecast of growth of mortality of the population in Ukraine from CVDs was made. In article by V. Handziuk (Handziuk et al, 2017) the main indicators of primary morbidity, prevalence of diseases and mortality of the population caused by circulatory system diseases are analyzed in regional aspect. The findings indicated the differentiation between regions of the primary morbidity rate, prevalence of diseases and index of accumulation of CVDs. In the article by V. Kovalenko (Kovalenko et al, 2013) the regional structure of the mortality of the population from CVDs is analyzed and a methodological approach proposed for the analysis of its structure. CVDs as medico-social and socio-political problems were considered in the works by V. Kovalenko and V. Kornatskiy (Kovalenko & Kornatskiy, 2013; 2014).

Medical-geographical investigations of mortality from CVDs of the population of Ternopil region were made by I. Demianchuk (Demianchuk, 2014), N. Fedishyn (Fedishyn, 2013). The prevalence of CVDs in Poltava region was studied by T. Pluznikova (Pluznikova, 2015). The analysis of population morbidity and mortality from CVDs in Transcarpathian region were examined in the article by Ya. Slivka & M. Virag (Slyvka, 2011). The mortality from CVDs of inhabitants of Kharkov region is considered in the article by A. Kotvitska & I. Lobova (Kotvitska, 2012); the scientific research on the main components of the population morbidity and mortality in Vinnitsa region was conducted by O. Hovorko (Hovorko, 2015). The territorial features of population morbidity and mortality from CVDs in the city of Kryvyi Rih are presented in work by D. Shyyan (Shyyan, 2012). In the Sumy region, the role of CVDs in the structure of mortality of the population has not been clarified. This is what determined the aim of our article.

The aim of the article is clarification of the geographical features of the mortality of the population of Sumy region from cardiovascular diseases.

Material and research methods. The observation covers the period from 2012 to 2018. This study analyzed the data of annual statistical reports of medical institutions of the Sumy region, which are subordinate to the Ministry of Public Health of Ukraine. This made it possible to establish regional differences in the mortality of the population (including separately the able-bodied population) from various types of CVDs: coronary heart disease, acute myocardial infarction, cerebrovascular disease, cerebral strokes and strokes with hypertension.

For determining the regional features of population mortality from cardiovascular diseases, we used the integrated indicator, proposed and named by N. Rogozinskaya as «disease mortality risk assessment» (Rogozinskaya, 2013):

$$EDdis = \frac{DRdis}{DIS} \cdot DISnew,$$

where: *EDdis* – integrated indicator «disease mortality risk assessment», characterizing the risk of dying from CVDs at this incidence rate (cases per 100 000 people); *DRdis* – mortality due to the disease (cases per 100 000 people); *DIS* – prevalence of the disease (cases per 100 thousand people); *DISnew* – primary morbidity by the disease (cases per 100 000 people).

Using the above-mentioned indicator makes it possible to increase the information content of the statistical analysis and make the best determination of the health dynamics of the population of the administrative-territorial districts.

Forecast of mortality rate from CVDs was grounded on the linear regression $a+bx$,

where $a=\bar{y}-b\bar{x}$, $b = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2}$,

where y – years of observation, x – observed mortality.

In the article a systems approach, cartographic, comparative geographic, forecasting analytical, statistics and other methods of scientific research were applied.

All calculations, figures and the graphic images were obtained using SPSS Statistic 17.0 computer software by SPSS Inc., Microsoft Excel 2010 and Statistica 10 by StatSoft Inc.

Results and discussion. In Ukraine in 2017 the mortality rate from CVDs was 907 cases per 100 000 people, that is, these diseases are the main cause of death (Shchorichna, 2018). Sumy region takes 11th place in the national rating of primary morbidity by pathologies of cardiovascular system (Kornus, 2017). As of January 1, 2019 in Sumy region CVDs take 1st place (57,459.63 cases per 100 000 people) in total prevalence of diseases among the population. In structure of this nosology class, arterial hypertension (26,199.26 cases per 100 000 people), coronary heart (18,900.88) and cerebrovascular (8,960.23) diseases are in the leading places.

We have studied the primary morbidity and prevalence of CVDs among the population of Sumy region and their territorial differences among administrative districts (Kornus, 2020). The highest primary morbidity rate is registered in Lypova Dolyna, Romny, Nedryhailiv, Krolevets and Okhtyrka districts. The

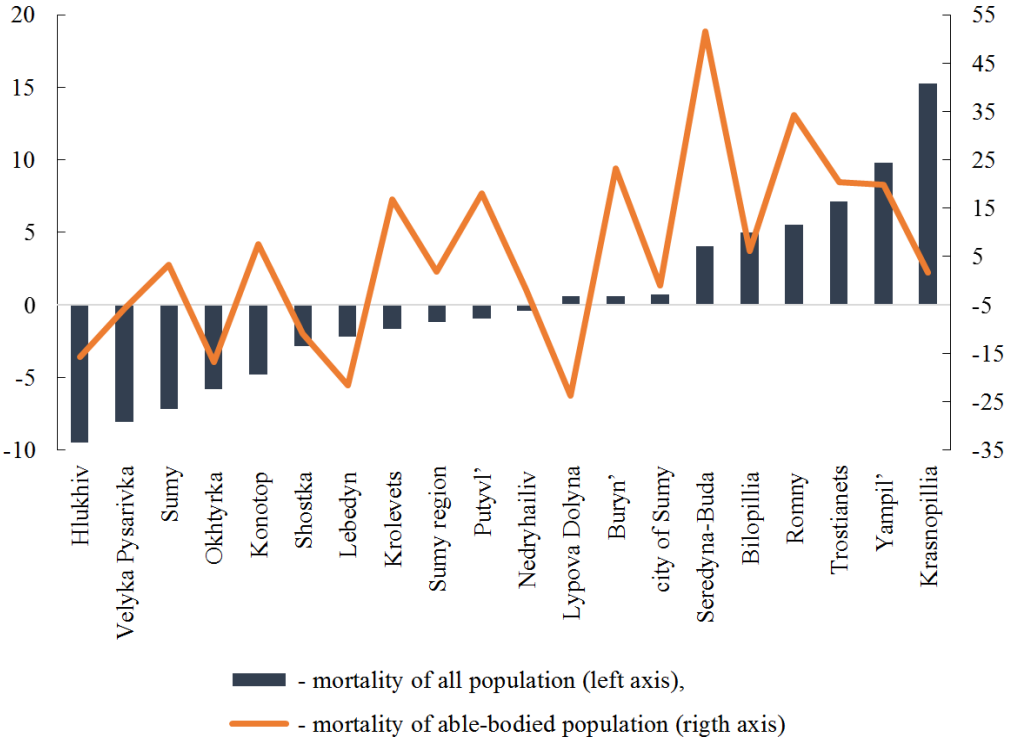

Fig. 1. Increase/decrease (%) of mortality rate from circulatory system diseases of the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019)

highest prevalence of CVDs is registered among the residents of Romny, Nedryhailiv, Lypova Dolyna and Lebedyn districts. In these districts cerebral strokes, strokes with hypertension, coronary heart disease, and myocardial infarction were observed most often.

According to medical statistics (Tablytsi, 2019) as of January 1, 2019 the mortality rate of the population (recalculation of actual total mortality rates in conditional indicators, calculated by fixed structure of the population (European standard)) from CVDs in Ukraine was 673.5 cases per 100 000 people. By this indicator Sumy region occupied 18th place among 23 administrative-territorial regions of Ukraine (excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and the temporarily occupied territories in the Donetsk and Luhansk regions). However, detailed study indicates significant differences in population mortality for specific reasons. For example, Sumy region occupied 20th place in Ukraine for mortality rate from coronary heart disease but 1st place (282.1 cases per 100 thousand people) for mortality rate from cerebrovascular diseases.

Among all administrative-territorial districts of the region, Romny (63,358.02), Velyka Pysarivka (62, 401.63), Lypova Dolyna (61,714.87), Bilopillia (61,350.86), Buryn' (60,426.99) and Nedryhailiv (60,325.27 cases per 100 thousand people) districts are the leading ones by prevalence of CVDs among the inhabitants.

In Sumy region during 2018 the mortality from CVDs was 1,045 per 100,000 people, including 131.5 per 100,000 of the able-bodied population. From 2012 to 2018 there was a decrease in mortality of population from these causes by 1.17 %. Among administrative-territorial districts, the greatest reduction of deaths from CVDs was in Hlukhiv (by 9.47 %), Velyka Pysarivka (by 8.05 %) and Sumy (by 7.18 %) districts, while in Trostianets (by 7.16 %), Yampil' (by 9.78 %) and Krasnopillia (by 15.28 %) districts deaths from the diseases of this nosology class increased.

In 2018 compared to 2012, there was an increase of mortality from CVDs among the able-bodied population by 1.94 %. However, in 8 administrative-territorial districts a decrease was observed, especially among the inhabitants of Okhtyrka (by 16.82 %), Lebedyn (by 21.67 %) and Lypova Dolyna (by 23.81 %) districts, while among inhabitants of 11 other districts an increase was recorded, especially among the residents of Seredyna-Buda (by 51.56 %), Romny (by 34.36 %) and Buryn' (by 23.3 %) districts (Fig. 1).

In spatial aspect, during 2018 the highest mortality from CVDs among the population was registered in Nedryhailiv (1,384.9), Yampil' (1,385.7) and Buryn' (1,478.8 cases per 100 000 people) districts. Among the able-bodied population the highest mortality level was in Putyvl' (202.9), Buryn' (204.8) and Romny (210.4 cases per 100 000 people) districts.

Arterial hypertension occupies the first place in the structure of CVDs of the population of Sumy re-

gion. This is a multifactorial disease, characterized by high blood pressure and is often the main cause of myocardial infarction, strokes, hypertensive crises, heart failure, chronic cerebrovascular diseases, etc. Factors influencing development of arterial hypertension include heredity, traumatic brain injuries, age-related changes of functioning of the nervous and endocrine systems, obesity, kidney disease, psychoemotional overload and stress, constant mental strain, physical inactivity, excessive consumption of salt, coffee, sugar (Kornus, 2018).

According to medical statistics (Dovidnyk, 2019) as of January 1, 2019 in Sumy region arterial hypertension was most common among the residents of Romny (29,227.81 cases per 100 000 people), Konotop (28,800.45) and Shostka (28,160.85) districts. The highest rates of primary morbidity by this pathology were in Romny (2,259.75), Krolevets (2,167.14) and Seredyna-Buda (2,139.33 cases per 100 thousand people) districts.

One of most common pathologies of the cardiovascular system is coronary heart disease. This disease includes angina pectoris, myocardial infarction and atherosclerotic cardiosclerosis. In the structure of CVDs it takes 1st place. The main factors causing development of this disease are an unhealthy lifestyle, including smoking, stress, high-calorie nutrition, arterial hypertension, diabetes mellitus, hereditary factors, hyperlipidemia, overweight, hypodynamia, age-related changes, various inflammations, as well as lack of preventive investigations, late diagnosis (Kornus, 2018). In Sumy region the highest prevalence rates of coronary heart disease are fixed among the inhabitants of Velyka Pysarivka (22,849.19), Lebedyn (21, 449.29) and Lypova Dolyna (21,071.66 cases per 100 000 people) districts. In 2018 by the number of newly registered cases of this pathology, the leaders were Lypova Dolyna (1,645.8), Putyvl' (1,387.86) and Okhtyrka (1,385.39 cases per 100 000 people) districts.

Mortality from coronary heart disease in the region during 2018 was 516.7 cases per 100 000 people. During the study period, the population mortality rate from this pathology fell by 2.51 %, including able-bodied population – by 6.68 %. It should be noted that in 10 administrative-territorial districts of the region reduction of mortality from coronary heart disease was recorded. However for such districts as Bilopillia (by 12.63 %), Seredyna-Buda (by 15.75 %) and Krasnopillia (by 25.39 %) high growth of the mortality rates in 2018 compared to 2012 was characteristic. Among the able-bodied population, deaths from coronary heart disease increased in Hlukhiv (by 32.71 %), Bilopillia (by 41.19 %) and Buryn' (twice) districts (Fig. 2).

In 2018 the highest rates of registered cases of death from coronary heart disease were observed in Buryn' (756.1), Lypova Dolyna (816.7) and Bilopillia (947.2 cases per 100 000 people) districts, the highest death rates among able-bodied population were in Yampil' (75.6), Romny (78.6) and Buryn' (90.1 cases per 100 000 people) districts.

Acute myocardial infarction is another common

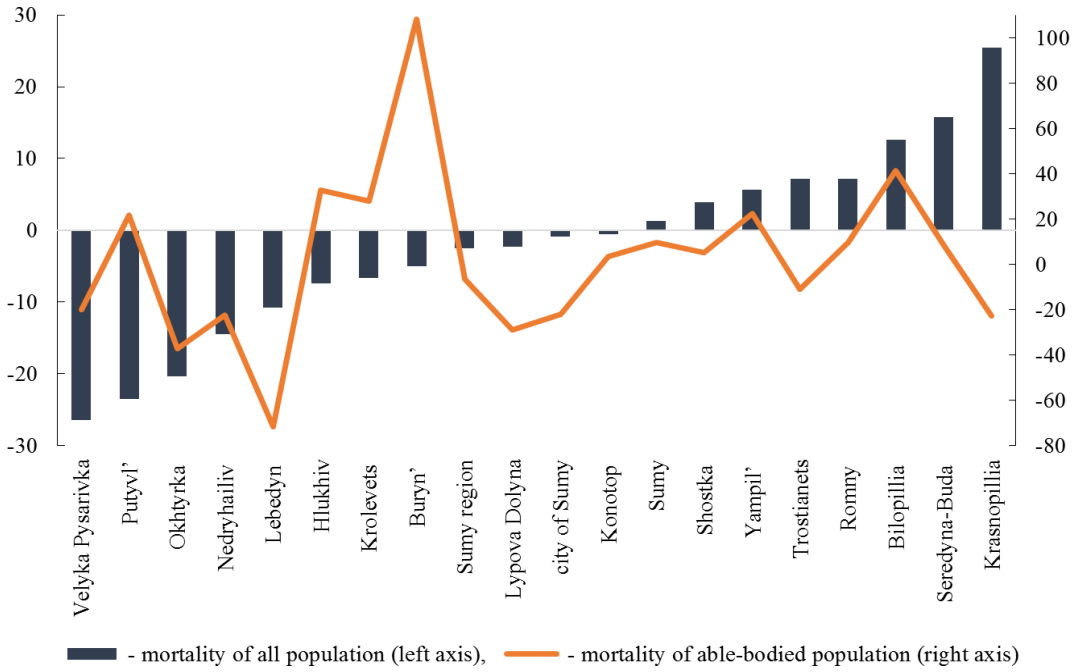

Fig. 2. Increase/decrease (%) of mortality rate from coronary heart disease among the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019).

reason of population mortality of the Sumy region. In 2018 in the region the mortality rate from myocardial infarction was 20.5 cases per 100 000 people. In 2018 compared to 2012, mortality from myocardial infarction in the region grew by 13.89 %. The highest mortality rate from myocardial infarction in 2018 was observed in such districts as Trostyanets (26.3), Shostka (29.3), Krolevets (29.5), Lebedyn (33.5) and Nedrihailiv (33.8 cases per 100 000 people). In 2018 only in Yampil' district were no cases of mortality from myocardial infarction registered, whereas at the same time in Nedryhailiv, Romny and Okhtyrka districts a 2-3 times growth in this indicator was registered (Fig. 3).

The negative point is the significant increase of mortality from myocardial infarction among the able-bodied population. During the study period the mortality by infarction in this age group grew by 71.05 %.

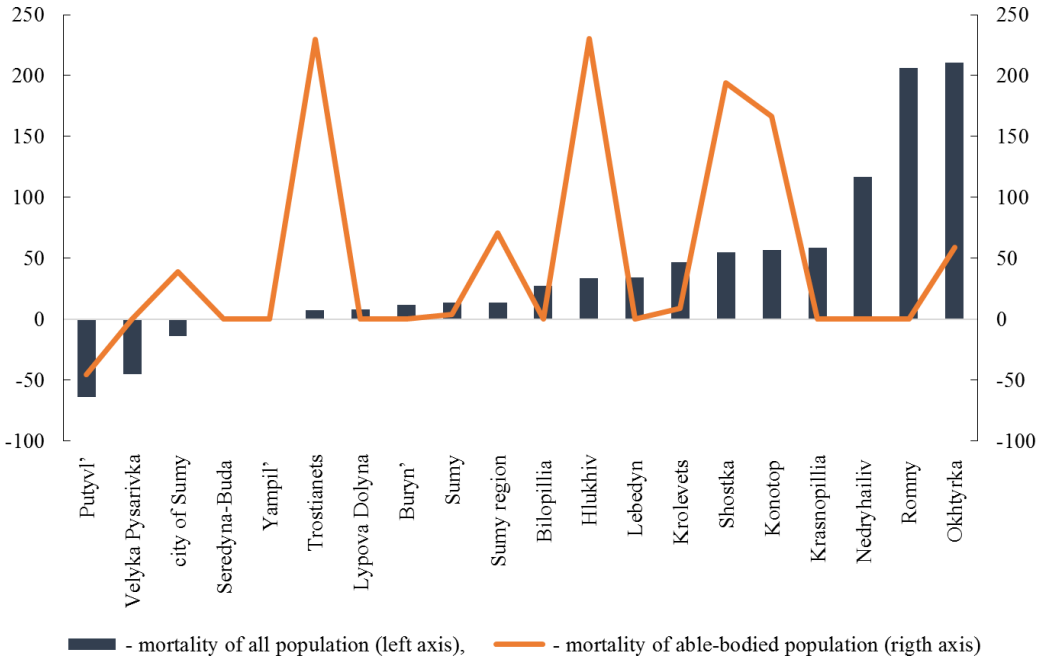

Fig. 3. Increase/decrease (%) of mortality rate from myocardial infarction among the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019).

Especially negative dynamics were observed among the inhabitants of Hlukhiv (by 3.3 times), Trostianets (by 3.2 times), Shostka (by 2.9 times) and Konotop (by 2.6 times) districts. The population mortality rate from myocardial infarction is most polarized: if in 7 districts of the region (Bilopillia, Buryn', Lebedyn, Lypova Dolyna, Romny, Seredyna-Buda and Yampil') in 2018 no cases of mortality from this pathology were registered among the able-bodied population, then in Shostka, Nedryhailiv, Trostianets and Hlukhiv districts myocardial infarction was cause of 14-18 deaths per 100 000 able-bodied inhabitants.

The 3rd place by level of morbidity of the Sumy region population is occupied cerebrovascular diseases. They include such pathologies as hemorrhage, cerebral infarction, cerebral strokes, blockage and stenosis of the cerebral and cerebral arteries, etc. The WHO experts noted that in 2000 CVDs became the cause of 9.2 % of world mortality (in high-income countries – 13.7 %, in low-income – 8 %). It should be noted that the number of strokes in the world is growing – about 16 million new cases are recorded annually, of which 5.7 million result in death (Global, 2017; Kornus, 2018). The main factors affecting the population morbidity by cerebrovascular diseases are high blood pressure, overweight, constant stress, unhealthy lifestyle, etc.

In 2018 the prevalence of cerebrovascular diseases in the region was 8,960.23 cases per 100 000 people). The highest prevalence of this pathology was observed among the population of Shostka (11,378.02 cases per 100 000 people), Buryn' (10,872.98) and Romny (10,364.51) districts. The highest primary incidence rates were characteristic for the inhabitants of Romny (1,130.57), Lypova Dolyna (1,106.19) and Shostka (908.58 cases per 100 000 people) districts.

In 2018 475.8 deaths from cerebrovascular diseases were registered per 100 000 inhabitants of Sumy region. Among administrative-territorial districts the highest population mortality rate from cerebrovascular diseases was in Buryn' (685.1), Putyvl' (722.2) and Velyka Pysarivka (728.0) districts. In 2018 compared to 2012 the mortality from cerebrovascular disease grew by 0.57 %. There are 12 administrative-territorial districts with negative mortality dynamics,

especially high mortality rates were in Buryn' (higher by 12.27 %), Yampil' (by 12.82 %) and Putyvl' (by 18.39 %) districts.

Among the able-bodied population the mortality rate from this pathology was 30.5 cases per 100 000 people. The highest mortality of working age people from cerebrovascular diseases was recorded in Velyka Pysarivka (58.8), Krasnopillia (62.4) and Buryn' (65.5 cases per 100 000 people) districts. Although for the research period the mortality level in the region decreased by 7.85 %, in 8 administrative-territorial districts it increased. This increase was especially characteristic of Krasnopillia (increase by 76.77 %), Velyka Pysarivka (mortality doubled) and Trostianets districts (increase by 2.5 times). Mortality rates did not change only in Konotop district – 37.3 cases per 100 000 people (Fig. 4).

In 2018 compared to 2012 the mortality from strokes increased in 14 districts of the region. Especially negative dynamics were characteristic of residents of Hlukhiv (increase by 62.42 %), Krasnopillia (by 62.45 %), Lebedyn (by 87.81 %) and Seredyna-Buda (by 2.5 times) districts (Fig. 5).

Geographical analysis of the population mortality from strokes in 2018 showed significant chorological differences. So, in Krolevets (101.8), Lebedyn (129.4) or Krasnopillia (176.1 cases per 100 000 inhabitants) districts the highest values of this indicator were registered, at the same time in Trostianets district only 29.2 cases of mortality per 100 000 people were recorded.

Mortality from strokes among the able-bodied population grew by 1.56 **%**. Only in 6 districts was the dynamic of mortality positive. In all other administrative-territorial districts increasing mortality

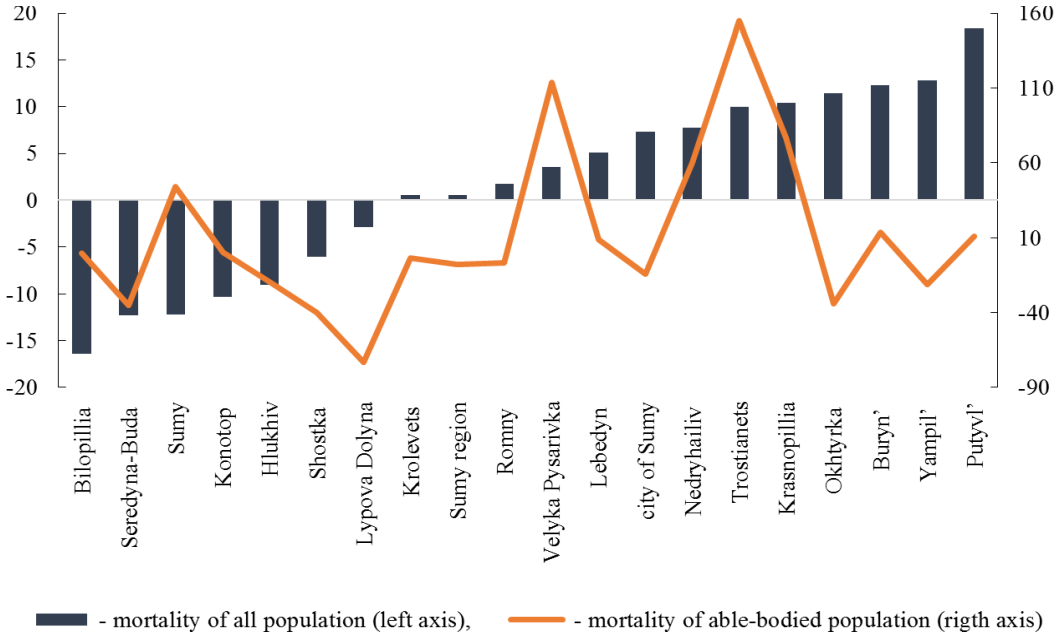

Fig. 4. Increase/decrease (%) of mortality rate from cerebrovascular diseases among the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019).

Strokes take 4th place among CVDs causing death of the population in Sumy region, especially among the working-age population. As of January 1, 2019 in the region 74.8 cases per 100 000 people were registered, which is more by 9.67 % than in 2012. It should be noted, among the residents of Ukraine there are 150 000 strokes per year (1/3 of them among the able-bodied population), 30-40 % of stroke patients die within a month after the event and up to 50 % – during 1 year from the onset of the disease, 20-40 % of recovered patients become dependent on assistance (12.5 % of all primary disability), and only 20 % return to a full life. This disease most often leads to temporary or permanent disability and significantly affects the quality of life of people (Insult, 2019).

from this category of nosology was registered. Especially high negative dynamics were characteristic for inhabitants of Krasnopillia (increase by 2.1 times), Trostianets (by 2.2 times) and Velyka Pysarivka (by 6.4 times) districts. Altogether, during 2018 the highest mortality among the able-bodied population was in Buryn' (49.1 cases per 100 000 people), Velyka Pysarivka (58.8) and Krasnopillia (62.4) districts. As can be seen, the two last districts are leaders by the number of deaths, as well as by the tempi of mortality dynamics during the entire period of research.

Also, in the structure of population mortality from CVDs one can distinguish strokes with hypertension. Most often, a stroke develops against the background of high blood pressure and is a complica-

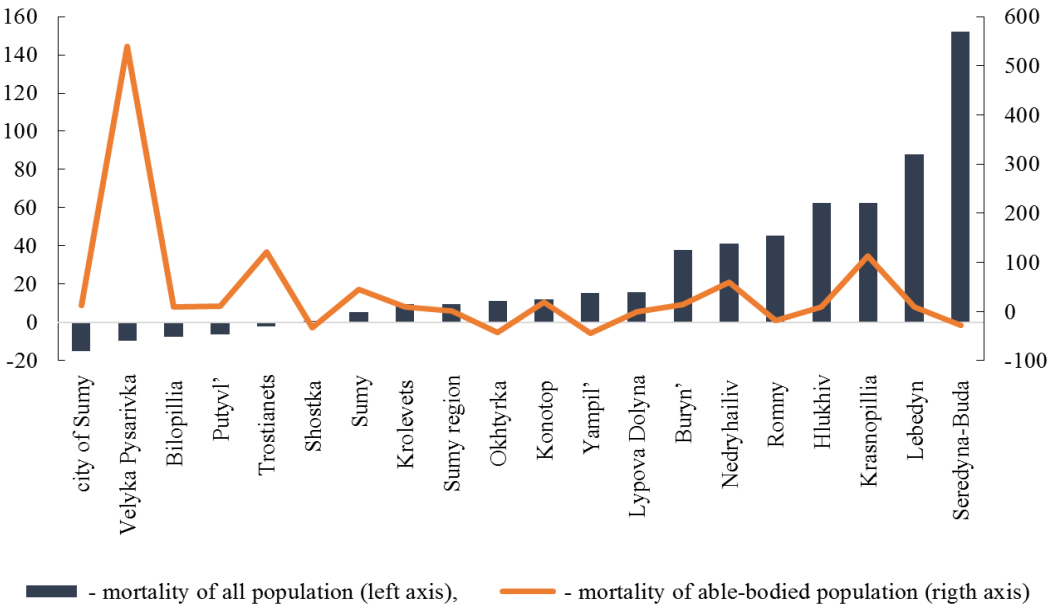

Fig. 5. Increase/decrease (%) of mortality rate from strokes among the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019).

tion of hypertension. As of January 1, 2019 in Sumy region 31.5 persons per 100 000 people died from this pathology. During the entire period of research the number of deaths from strokes with hypertension decreased by 6.25 % and among able-bodied population by 37.8 %. However, among the 19 administrative-territorial districts of the region an increase in the mortality rate was observed in 11. Increase was especially characteristic in Romny (by 2 times), Lebedyn (by 2.1 times), Bilopillia (by 3.1 times), Buryn' (by 3.7 times), Nedryhailiv (by 4.3 times) and Seredyna-Buda (by 6.5 times) districts. Only in Krolevets district during 2018 were no cases of mortality registered from this category of nosology But the greatest number of deaths from this pathology occurred among the residents of Shostka (57.5), Sumy (59.2) and Lebedyn (95.9 cases per 100 000 people) districts (Fig. 6).

During 2018 cases of mortality from strokes with hypertension were not registered in 7 districts of the region mortality cases (Velyka Pysarivka, Hlukhiv, Krasnopillia, Krolevets, Lypova Dolyna, Nedryhailiv and Yampil' districts). At the same time from 2012 to 2018 the mortality from this pathology grew in 8 districts. An especially unfavourable situation was observed among the able-bodied population of Sumy, Putyvl', Trostianets, Romny and Bilopillia districts, where twofold growth of deaths from strokes with hypertension was fixed.

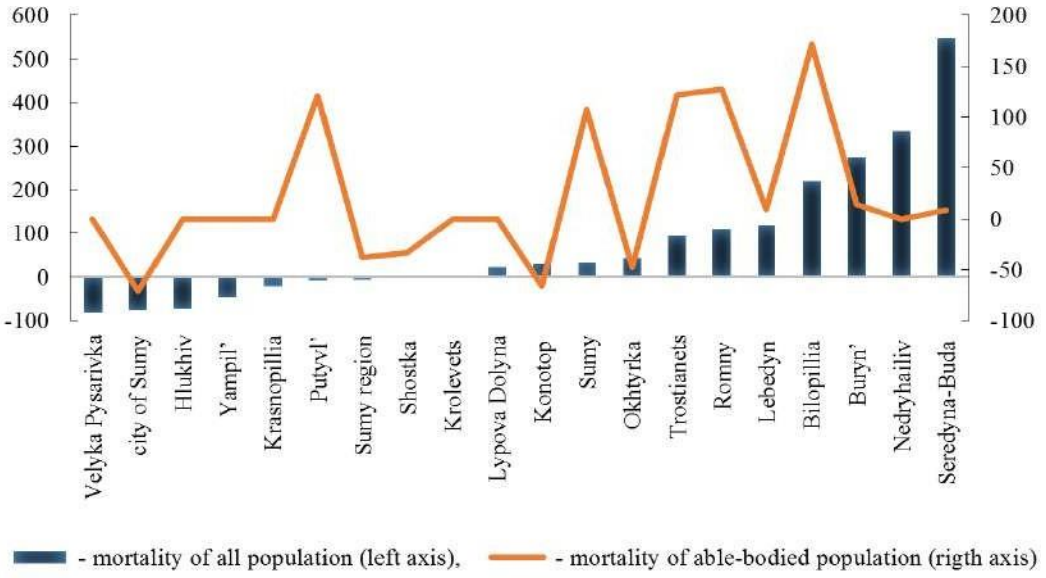

Fig. 6. Increase/decrease (%) of mortality rate from strokes with hypertension among the population of Sumy region in 2018 compared to 2012 (Source: Dovidnyk, 2013, 2019).

To establish the level of risk of death from CVDs for the population of Sumy region we used the above-mentioned integrated indicator «disease mortality risk assessment». This indicator takes into account the relationship between the primary morbidity, prevalence of diseases and the causes of mortality and makes it possible to assess the state of the population's heath in terms of CVDs.

So, with high morbidity and low mortality, prevalence of diseases will be fairly high and integrated indicator value low. The integrated indicator value at the low level of prevalence of diseases and mortality will depend on the morbidity rate. If there is low morbidity and high mortality, the prevalence of diseases will be low, however the integrated indicator «disease mortality risk assessment» will be high. If there are high morbidity and mortality rates and low prevalence of CVDs, then the value of the integrated indicator will be high. An integrated approach allows one to make a comparative analysis of different administrative-territorial districts and different diseases that reduces estimation errors. Use of this indicator will increase the information content of the analysis of population mortality among administrative-territorial districts and also allow assessment of the mortality risk from CVDs taking into account the total cases of diseases as well as the primary morbidity and prevalence of diseases (Rogozinskaya, 2013).

Analysing the «disease mortality risk assessment» characterizing the risk of dying from CVDs at this morbidity rate, we obtained the following results. The highest mortality risks from CVDs are for the inhabitants of Sumy, Romny, Nedryhailiv, Putyvl' and Lypova Dolyna districts, where the highest integrated indicator value was observed. At the same time for the city of Sumy, Bilopillia and Krasnopillia districts low level of the mortality risk from CVDs is characteristic (Table).

Among the individual nosologies, a high level of mortality risk from coronary heart disease was characteristic for the inhabitants of Buryn', Sumy and Lypova Dolyna districts. In Lebedyn and Nedryhailiv districts high rates of mortality risk from myocardial infarction were fixed. Among the residents of Putyvl', Romny, Velyka Pysarivka and Yampil' districts high mortality risk from cerebrovascular diseases was observed .High risk of death from cerebral strokes was characteristic for Krolevets, Lebedyn and Krasnopillia districts. Analyzing the mortality risks from strokes with hypertension we found 4 districts in which the levels of the integrated indicator are high – Bilopillia, Shostka, Sumy and Lebedyn.

Studying of the risk of mortality from CVDs among the able-bodied population of Sumy region, we found two districts where the values of the integrated indicator of risk are high – Seredyna-Buda and Yampil'. Among this age group, the population of Yampil', Buryn' and Hlukhiv districts was at the highest mortality risk from coronary heart disease. The mortality risk from myocardial infarction was highest in Shostka, Nedryhailiv, Trostianets and Hlukhiv districts. The risk of dying from coronary heart disease was highest among the residents of Buryn', Seredyna-Buda, Velyka Pysarivka and Yampil' districts. The highest rates of the risk of mortality from cerebral stroke were characteristic for Buryn', Velyka Pysarivka and Krasnopillia districts, and from strokes with hypertension – among the inhabitants of Shostka, Putyvl' and Bilopillia districts.

To forecast the population mortality of Sumy region, a forecast up to 2023 was made. The baseline scenario showed a decrease in mortality from CVDs by 2.1 % or to level 1021.88 per 100 000 people. According to the optimistic forecast (lower 95% confidence bound) the mortality rate from CVDs for 2023 will fall by 19.4% or to level 840.03 cases per 100 000 people. The pessimistic forecast (upper 95% confidence bound) shows an increase in the mortality rate by 13.3 % or 1,203.74 cases per 100 000 people (Fig. 7).

Conclusions. The study assessed the mortality of the population of Sumy region from CVDs. In 2018 the mortality level of the overall population of Sumy region compared to 2012 decreased by 1.17 %, but mortality of the able-bodied population on the contrary grew by 1.94 %.

Based on the use of the integrated indicator «disease mortality assessment» we identified the districts with the worst situation with CVDs. Taking into account the primary morbidity and prevalence of these diseases among the residents of the region, the population mortality risk from CVDs was established. The geographical features of mortality were clarified and we identified 9 administrative-territorial districts where during the study period the total mortality of the population from this class of pathology increased.

As for the able-bodied population, the mortality rate in this age group increased in 11 districts. This indicates a negative trend of CVDs morbidity and requires increased attention from the local authorities.

In general, having ranked the indicators of the mortality risk from CVDs, we found that the greatest risk is of death from a stroke, in the second place – from cerebrovascular diseases, and in third place – from strokes with hypertension. Next are the risks of dying from coronary heart disease and myocardial infarction. Among the causes of mortality of the able-bodied population, cerebral strokes take the first place,

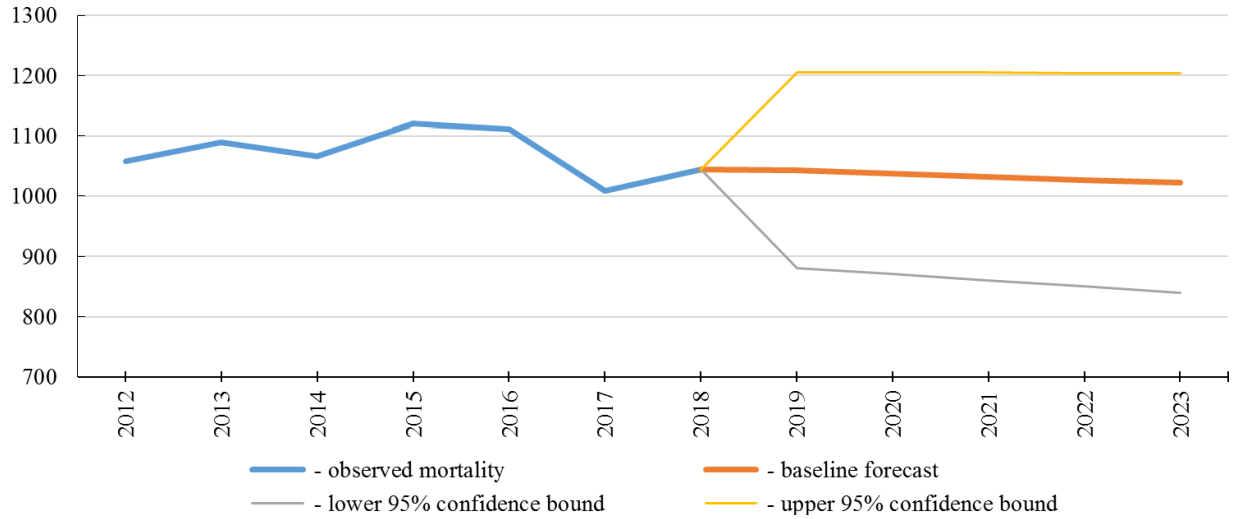

Fig. 7. The forecast of the mortality rate from CVDs of the population of Sumy region before 2023 (deaths per 100 000 people).

Table. The risk of population mortality of the Sumy region from CVDs, cases per 100 000 people as of January 1, 2019

Administrative-territorial districts	All population						Able-bodied population					
	The mortality risk from CVDs	The mortality risk from coronary heart disease	The mortality risk from acute myocardial infarction	The mortality risk from cerebrovascular diseases	The mortality risk from cerebral strokes	The mortality risk from strokes with hypertension	The mortality risk from CVDs	The mortality risk from coronary heart disease	The mortality risk from acute myocardial infarction	The mortality risk from cerebrovascular diseases	The mortality risk from cerebral strokes	The mortality risk from strokes with hypertension
Sumy region	72.07	29.40	20.50	38.83	74.80	31.50	12.96	4.06	6.50	5.87	25.90	9.20
City of Sumy	42.46	14.39	22.50	28.42	63.40	12.00	8.20	2.31	5.70	4.66	21.50	3.80
Bilopillia	51.91	29.73	12.10	12.37	66.80	54.60	9.34	2.14	0.00	5.70	40.00	36.40
Buryn’	98.53	47.08	12.50	41.37	87.70	41.80	22.56	10.56	0.00	11.56	49.10	8.20
Velyka Pysarivka	92.25	25.24	10.90	67.19	98.50	5.50	18.63	6.39	9.80	16.04	58.80	0.00
Hlukhiv	80.59	35.17	18.00	40.22	73.90	7.20	19.67	15.86	18.50	5.21	27.80	0.00
Konotop	71.58	28.92	17.70	35.35	75.00	37.90	12.68	1.82	7.20	5.89	30.10	8.60
Krasnopillia	61.57	21.89	10.80	38.25	176.10	28.80	10.95	3.58	6.20	7.38	62.40	0.00
Krolevets	89.31	36.43	29.50	46.59	101.80	0.00	15.36	7.19	4.80	7.14	33.30	0.00
Lebedyn	81.96	35.49	33.50	36.93	129.40	95.90	12.40	2.94	0.00	5.25	23.90	16.00
Lypova Dolyna	116.37	63.79	21.90	55.58	82.20	43.90	11.51	3.88	0.00	1.67	0.00	0.00
Nedryhailiv	108.08	43.62	33.80	48.15	71.80	16.90	18.62	6.40	14.90	4.72	22.40	0.00
Okhtyrka	73.62	34.43	20.20	34.69	56.60	28.30	14.02	5.15	7.00	4.27	14.00	7.00
Putyvl’	110.77	32.77	3.70	63.04	48.40	18.60	20.16	6.73	6.30	5.49	38.00	25.40
Romny	107.76	41.72	23.60	65.74	92.80	34.60	14.40	3.63	0.00	6.68	25.40	15.20
Seredyna-Buda	92.52	44.66	6.30	41.78	43.90	37.60	28.90	5.84	0.00	13.60	21.50	10.70
Sumy	102.18	49.72	14.40	50.85	73.60	59.20	9.29	4.59	2.80	2.83	19.30	11.00
Trostianets	64.29	31.04	26.30	17.77	29.20	26.30	10.93	2.33	15.50	6.28	10.40	10.40
Shostka	71.36	21.67	29.30	44.36	68.00	57.50	17.44	6.40	14.40	4.77	25.10	19.70
Yampil’	93.07	39.29	0.00	70.08	73.60	13.00	30.66	10.48	0.00	20.16	22.70	0.00

strokes with hypertension – the second place, and the risks of mortality from myocardial infarction are in the third place. There is a lower risk of dying in this age group from cerebrovascular diseases and coronary heart disease. It should be noted that the residents of Sumy, Romny, Nedryhailiv, Putyvl' and Lypova Dolyna districts have the highest mortality risk from CVDs, but among the able-bodied population the risk is highest for the inhabitants of Seredyna-Buda and Yampil' districts.

The results of the study can be used by local authorities to prevent the growth of morbidity and mortality from diseases of this nosological class, as well as for development of preventive measures and stabilization of the health status of the population of Sumy region.

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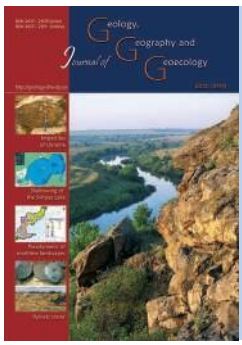

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New data about the distribution of nickel, lead and chromium in the coal seams of the Donetsk-Makiivka geological and industrial district of the Donbas

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Abstract. A modern and scientifically based indicators forecast of toxic and potentially toxic element concentrations allows us to develop and plan organizational and technical-technological measures aimed at reducing the negative impact of the coal industry and heating enterprises on the ecological state of the environment. For this purpose it is necessary to have data about concentration, character and features of the distribution of toxic and potentially toxic elements, including nickel, lead and chromium in coal and the rocks that contain it. Toxic elements are one of the main sources of environmental pollution that negatively affects human health. Research in this direction is conducted to reduce the degree of negative effects and additional pollution of the environment. Increasing requirements for environmental protection in the coal-mining industry sector of Ukraine stipulates the need for new scientifically grounded methods for forecasting the content of toxic and potentially toxic elements in the rock mass which is extracted by mines, the waste of coal extraction and coal enrichment and also the influence of the coal-heating enterprises on the environment. In the article, the results of investigations of toxic elements in coal seams of the Donetsk-Makiivka geological and industrial area of the Donbas are considered. The research covered the whole territory of one of the most studied geological and industrial districts of the Donbas – Donetsk-Makiivka. As a result of the study, correlation coefficients were calculated that allow us to predict the concentration of nickel, lead and chromium in the products and wastes of coal enrichment and correct the technological schemes of coal enrichment taking into account their content. We also calculated the regression equation between these elements and the ash content of the coal, which will allow us to predict their concentration in the main working coal seams of the Donetsk-Makiivka geological and industrial districts relative to the values of coal ash content. The character of the distribution is established and the weighted average concentrations and basic descriptive statistics for nickel, lead, and chromium in the coal seams and suites are calculated. The composition and character of their typomorphic geochemical associations, as well as the features and regularities of their accumulation in the coal seams of the Donetsk-Makiivka geological and industrial districts are revealed.

Keywords: toxic elements, potentially toxic elements, geological and industrial area, geochemical association, correlation coefficient, regression equation, statistical relationship

Нові дані про розподіл нікелю, свинцю та хрому у вугільних пластах Донецько-Макіївського геолого-промислового району Донбасу

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Анотація. Сучасний та науково обґрунтований прогноз показників концентрацій токсичних і потенційно токсичних елементів дозволяє розробляти та планувати організаційні і техніко-технологічні заходи, що спрямовані на зменшення негативного впливу вуглевидобувної промисловості та підприємств теплоенергетики на екологічний стан навколишнього середовища. Для цього необхідно мати дані про концентрацію, характер й особливості розподілу токсичних і потенційно токсичних елементів, у тому числі нікелю, свинцю й хрому у вугіллі та породах, які його вміщують. Токсичні елементи є головним джерелом забруднення навколишнього середовища, що негативно впливає на здоров'я людини. Дослідження в цьому напрямі прово-

дяться для зменшення ступеня негативного впливу і додаткового забруднення навколишнього середовища. Зростання вимог до охорони навколишнього середовища у вуглевидобувній галузі України зумовлює потребу в нових науково обґрунтованих методах прогнозу вмісту токсичних і потенційно токсичних елементів в гірничій масі, що видобувається шахтами та у відходах вуглевидобутку і вуглезбагачення, а також впливу підприємств вугільної теплоенергетики на навколишнє середовище. В статті розглянуто результати досліджень токсичних елементів у вугільних пластах Донецько-Макіївського геолого-промислового району Донбасу. Дослідження охопили всю територію одного з найбільш вивчених геолого-промислових районів Донбасу – Донецько-Макіївського. В результаті дослідження розраховані коефіцієнти кореляції, які дозволять прогнозувати концентрацію нікелю, свинцю та хрому у продуктах та відходах вуглезбагачення й корегувати технологічні схеми збагачення вугілля з урахуванням їх вмісту. А також рівняння регресії між цими елементами і зольністю вугілля, що дозволить прогнозувати їх концентрацію у основних робочих вугільних пластах Донецько-Макіївського геолого-промислового району відносно значень зольності вугілля. Встановлено характер розподілу та розраховані середньозважені концентрації та основні описові статистики для нікелю, свинцю та хрому у вугіллі основних пластів і світ. Виявлено склад і характер їх типоморфних геохімічних асоціацій, а також особливості й закономірності їх накопичення у вугільних пластах Донецько-Макіївського геолого-промислового району.

Ключові слова: токсичні елементи, потенційно токсичні елементи, геолого-промисловий район, геохімічна асоціація, коефіцієнт кореляції, рівняння регресії, статистичний зв'язок

Introduction. The Donetsk-Makiivka geological and industrial districts is located within Donetsk region, it occupies the central part of the industrial Donbas and has an area of 3170 km^2. The area is represented by a wide range of grade composition of coal from early to late catagenesis (Baranov, 2014) (from coal of rank D and G in the west to T and semi-anthracite in the east).

In previous works V.V. Ishkov together with A.I. Chornobuk, D.Ya. Mykhalchonok, V.V. Dvoretskyi, A.B. Moskalenko (Ishkov, 2000-2001) studied the peculiarities of the distribution of these elements in the products and enrichment wastes of a range of processing plants of Donbas. The forecast and assessment of concentrations of toxic and potentially toxic elements in coal within the Chystiakovo-Snizhnianskyi geological and industrial districts, in particular in the system of coal - rock mass - enrichment products were carried out by I.I. Kurmelov, V.V. Ishkov, M.A. Dobrohorskyi, V.P. Shevchenko, I.L. Safronov (Dobrohorskyi, 1999; Ishkov, 1999). V.V. Ishkov together with Ye.S. Kozii considered the peculiarities of distribution of toxic and potentially toxic elements in the coal seams of Pavlohrad-Petropavlivka (Ishkov, 2017; Koziy, 2017; Koziy, 2018; Nesterovskyi, 2020) and Chervonoarmiisk (Ishkov, 2019) geological and industrial areas. Ecological aspects of the geochemistry of toxic elements in the coal seams of many deposits in the world are considered in the works of D. Swaine (Godbeer, et al., 1984; Swaine, 1990). Numerous studies of their distribution in the coal of different deposits have shown that the composition and content of these elements and their distribution are different for each deposit, and within individual deposits also depends on the stage of carbonization (Martinez-Tarazona et al., 1992; Mercer et al., 1993; Pires and Teixeira, 1992; Solari et al., 1989; Spears and Martinez-Tarazona, 1993; Vassilev, 1994).

Research methodology. Samples were taken in the mines strata samples taken by the furrow method) (GOST, 1975) and from duplicates of the core personally by the authors with the participation of employees of geological services of coal mining enterprises and production exploration organizations in the period from 1981 to 2013. The volume of the control sampling was 5% of the total sample volume. All analytical works were performed in the central certified laboratories of industrial geology-prospecting organizations. The content of the elements was determined by quantitative emission spectral analysis (GOST, 1991). 7% of duplicate samples were sent for internal laboratory control. 10% of duplicate samples (correctness and reproducibility) were evaluated as the significance of the average systematic error, which is checked by Student's test, and the significance of the average random error, which is checked by Fisher's test. As the above-mentioned discrepancies in the level of significance 0.95 are not significant, the quality of the analyses is considered satisfactory.

Using Excel 2016 and Statistica 11.0 at the initial stage of processing primary geochemical information, the values of basic descriptive statistical indicators were calculated, frequency histograms of content were constructed and the law of distribution of nickel, lead and chromium was established. When assessing the relationship of these elements with the organic or mineral part of the coal we used the coefficients of affinity with organic matter Fo, which shows the ratio of the content of elements in coal with low (<1.6) and high density (> 1.7), the coefficients of the concentration Fnk showing the ratio of the content of elements in the fraction i(Ci) to the content in the original coal, the correlation coefficients of the content of the investigated elements and the ash content of coal and the coefficients of the reduced extraction of the element in the fraction of different densities.

In the construction of graphs and calculation of correlation coefficients, all values of elements concentrations and technological parameters of coal were normalized according to the formula:

$X_{norm.} = (X_i - X_{min}) / (X_{max} - X_{min})$, where: X_i is the result of a single value of the element concentration; X_{max} - the result of the maximum value of the element concentration; X_{min} is the result of the minimum value of the element concentration. Normalizing was performed for transformation of the data selection to the same scale, regardless of the units and scale of the samples.

Research results. During the study, the main tasks of studying the geochemistry of potentially toxic elements in the main working coal seams of the district were the revision of previous studies of nickel, lead and chromium, the formation of representative samples of their content in individual coal seams and the districts as a whole; analysis of the distribution of their content in the whole area; establishing the average content of these elements in the coal seams, the suites and the districts as a whole; identification of connections and calculation of regression equations between the content of these elements, the petrographic composition of coal and its main technological parameters. The source material characterizes the concentration of nickel, lead and chromium in 64 coal seams belonging to the suites C_2^2 (seams $g^в$), C_2^3 (seams h_1^2, h_1^2, h_1^1, h_1^1, h_1^3, h_1^4, h_1^5, h_1^6, h_1^6, h_1^7, h_1^8, h_1^8, h_1^{10}), C_2^4 (seams i_1^2, i_1^5, i_1^1), C_2^5 (seams k_1^8, k_1^{10}, k_1^{10}, k_2^2, k_2^{10}, k_2^{10}, k_2^{10}, k_2^{10}, k_2^1, k_2^2, $k_2^{2в}$, k_2^2, k_2^1, $k_2^н$, k_2^1, k_2^2, k_2^1, k_2^3, k_2^3), C_2^6 (seams $l_1^н$, l_1^1, $l_1^в$, l_1^4, l_1^5, l_1^5, l_1^1, l_1^6, l_1^6, l_1^7, l_1^7, l_1^1, l_1^8, l_1^8, l_1^1, l_2^2), C_2^7 (seams m_1^1, m_1^1, m_2^2, m_3^3, m_3^4, m_4^6, m_4^6, m_4^4, m_5^7, m_5^7, m_5^8, m_7^1, m_7^8, m_9^2) and C_3^1 (seams $n_1^н$, n_1^1, $n_1^в$) of the middle and upper parts of the coal period. For the purpose of obtaining the most objective and comparable data, the results of semi-quantitative, quantitative analyses of coal core samples of mine fields, as well as reserve and exploration areas and sites within the district performed after 1983 in the central certified laboratories of geological exploration organizations were used. In some cases, they were supplemented by analyses of stratum-differentiated samples taken personally by the authors or together with employees of geological services of industrial exploration and productional organizations. The most representative (Beus, 1981, Havryshyn, 1980) results were obtained in 52 seams: $g^в$, h_1^2, h_1^1, h_1^1, h_1^3, h_1^4, h_1^5, h_1^6, h_1^6, h_1^8, h_1^8, h_1^{10}, $h_1^н$, h_1^1, $h_1^в$, h_1^1, i_2^5, i_2^1, k_2^1, k_2^2, k_2^2, k_2^3, k_2^4, $k_2^н$, k_2^5, $k_2^{в+н}$, k_2^6, $k_2^в$, k_2^1, k_2^{10}, k_2^2, k_2^{10}, $k_2^{2в}$, k_2^{10}, k_2^1, k_2^1, k_2^2, $k_2^н$, k_2^1, k_2^2, k_2^2, $k_2^н$, k_2^3, k_2^3, $l_1^н$, l_1^3, $l_1^в$, l_1^3, l_1^1, l_1^4, l_1^1, l_1^4, l_1^1, l_1^5, l_1^1, l_1^5, m_2^6, m_3^6, m_3^7, m_5^8, m_5^8, m_7^1, m_9^2, $n_1^н$, n_1^1 and $n_1^в$, lying within the fields of the mines «O.F. Zasyadka»,»Pokhila», «Hlyboka”,“Kalynivska Skhidna», «Chaikino», «Panfilovska», «№10-bis», «named after. E. Kalinin», «№ 2», «№ 12-18», «named after V.I. Lenin», «named after O.O. Skochynskoho», «Zhovtnevyi Rudnyk», «Butivska», «Butivka-Donetska», «Yasynivska Hlyboka», «Mushketivska», «Zaperevalna», «№6 Chervona Zirka», «Lidiyivka», «named after Chelyuskintsev», «named after Batova»,»Proletarskaya-Kruta», « named after Ordzhonikidze», «named after E.T. Abakumov»,» named after S.M. Kirov», «named after K.I. Pochenkova», «Trudovskaya», «Soviet», «named after V.M. Bazhanov», «№9 Capitalna», «№11-bis», «№13-bis», «№21», «named after Gorkyi», «Gruzska-pokhila», «Kuibyshevska», «Zhovtneva», «60 years of Soviet Ukraine», «Mospinska», as well as the exploration and reserve areas and fields»Novomospinska Zahidna», «Makiivo-Smolyanynivska», «Butivska Hlyboka №2», «Abakumivska-Hlyboka», «Ordzhonikidzevska-Hlyboka №2-4», « Ordzhonikidzevska-Hlyboka №3-5», «Georgiivska-Hlyboka», «Kirovska-Hlyboka», «Rutchenkivska», «Avdiivskii», «Trudovska-Hlyboka». To obtain representative estimates of the concentrations of nickel, lead and chromium in coal, both individual seams, suites and the district as a whole, individual determinations were combined for individual seams in 52 sampled objects, and further calculation of average content values was performed as weighted averages on the volume of the object. The volume calculations took into account the average thickness of the formation within the object, and the areas of reliably established erosion and protrusion of the seams were not taken into account. The sample average content in coal seams by suites is:

for Ni

C_2^2 – 23.5 gramm/ton, C_2^3 – 21.0 gramm/ton, C_2^4 – 38.3 gramm/ton, C_2^5 – 20.9 gramm/ton, C_2^6 – 18.6 gramm/ton, C_2^7 – 12.9 gramm/ton, C_3^1 – 17.2 gramm/ton, as a whole within the district – 18.3 gramm/ton;

for Pb

C_2^2 – 10.3 gramm/ton, C_2^3 – 10.6 gramm/ton, C_2^4 – 8.3 gramm/ton, C_2^5 – 12.1 gramm/ton, C_2^6 – 8.9 gramm/ton, C_2^7 – 4.5 gramm/ton, C_3^1 – 8.5 gramm/ton, as a whole within the district – 9.0 gramm/ton;

for Cr

C_2^2 – 36.3 gramm/ton, C_2^3 – 24.8 gramm/ton, C_2^4 – 31.7 gramm/ton, C_2^5 – 35.3 gramm/ton, C_2^6 – 26.4 gramm/ton, C_2^7 – 8.7 gramm/ton, C_3^1 – 22.6 gramm/ton, as a whole within the district – 23.0 gramm/ton.

It was found that for lead in five, and for nickel and chromium in two cases, the differences be-

tween the sample average concentrations in the coal of the closest stratigraphically investigated seams are statistically insignificant. Accordingly, these are pairs of seams: $h_2^1 - h_1$; $h_8 - h_2^3$; $k_2^2 - m_5$; $m_2^1 - m_7$; $n_1 - n_1^в$; $h_8 - h_8^н$; $m_{10} - m_5^1$; $h_5^3 - h_5^1$; $m_2^1 - m_2^2$; $m_5 - m_7$; the difference between the sample average content of these elements in the coal seams of neighboring suites is significant in all cases, the gradient between the sample average concentrations of these elements in the coal seams reaches the highest value in suites C_2^4 and C_2^6, and the lowest in suites C_2^3 and C_2^7. The significance of the differences between the sample average content of the mentioned elements in the coal of the nearest stratigraphic section seams and the suites was established using the program Statistica 11.0 (Borovykov, 2001) by calculating the t-test and Mann-Whitney U-test (as the most powerful nonparametric alternative to t-test) with a significance level of $p \leq 0.05$.

The analysis revealed the direct correlation of the nickel content with chromium r = 0.74, with the ash content of coal r = 0.59, the average relationship with lead r = 0.49, and also the weak direct correlation of this element with the total sulfur content r = 0.16. Linear regression equations (Fig. 1-4):

$$Ni = 0.09676 + 0.43074 \times A^d;$$
$$Ni = 0.21231 + 0.11468 \times S_t^d;$$
$$Ni = 0.09865 + 0.41619 \times Pb;$$
$$Ni = 0.04461 + 0.68900 \times Cr.$$

The analysis revealed the direct correlation of the lead content with chromium r = 0.68, with the ash content of coal r = 0.66, the average bond with nickel r = 0.49, and also a weak direct relationship of this element with the total sulfur content r = 0.23. Linear regression equations (Fig. 5-8):

$$Pb = 0.17147 + 0.56865 \times A^d;$$
$$Pb = 0.30743 + 0.19181 \times S_t^d;$$
$$Pb = 0.23384 + 0.58704 \times Ni;$$
$$Pb = 0.15054 + 0.75583 \times Cr.$$

The analysis revealed the direct correlation of the chromium content with nickel r = 0.74, with lead r = 0.68, with the ash content of coal r = 0.69, and also a weak direct correlation of this element with the sulfur content of total r = 0, 18. Linear regression equations (Fig. 9-12):

$$Cr = 10900 + 0.53691 \times A^d;$$
$$Cr = 0.25561 + 0.13663 \times S_t^d;$$
$$Cr = 0.10497 + 0.79690 \times Ni;$$
$$Cr = 0.07236 + 0.61976 \times Pb.$$

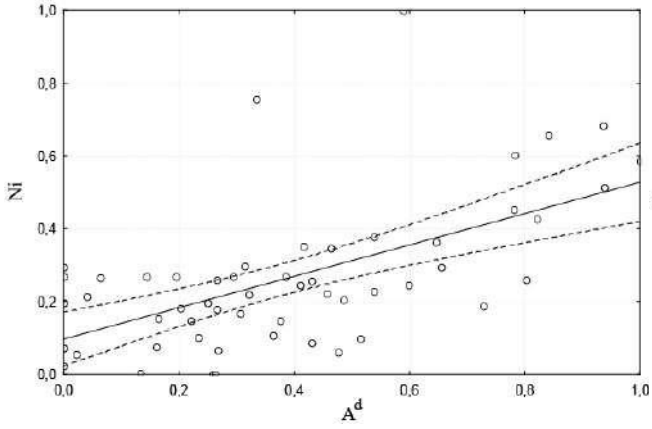

Fig 1. Regression line between the weighted average normalized value of nickel content and ash content of coal

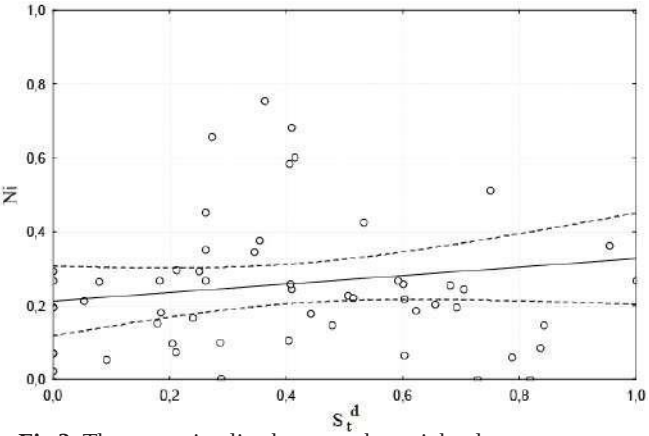

Fig 2. The regression line between the weighted average normalized values of nickel and total sulfur

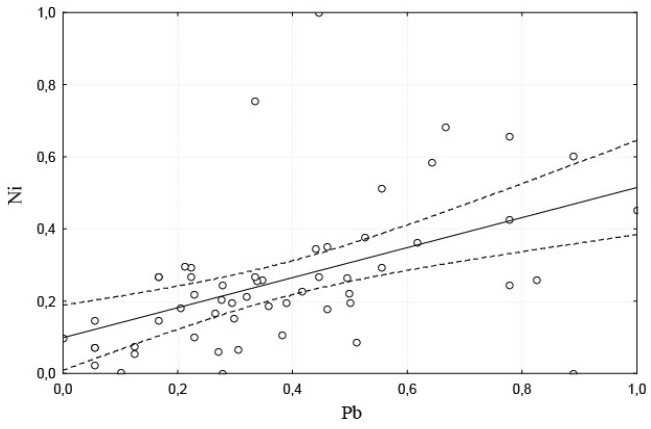

Fig. 3. Regression line between the weighted average normalized values of nickel and lead content

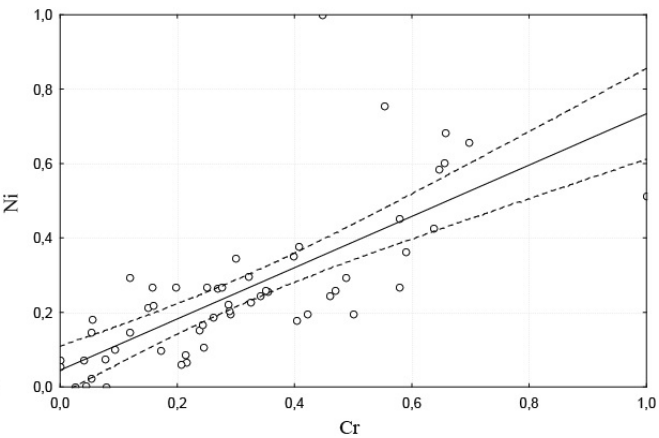

Fig. 4. The regression line between the weighted average normalized values of nickel and chromium

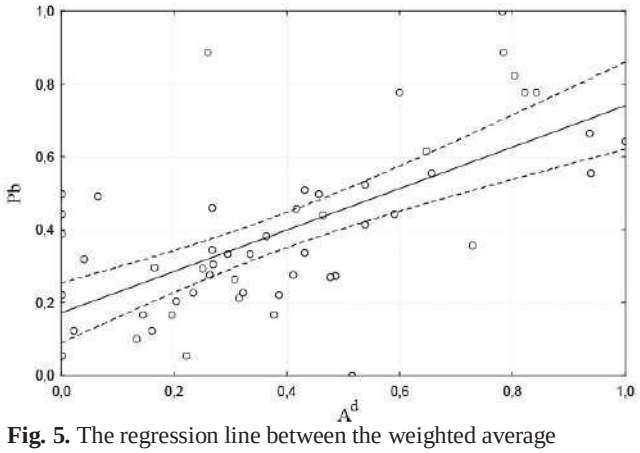

Fig. 5. The regression line between the weighted average normalized value of lead content and ash content of coal

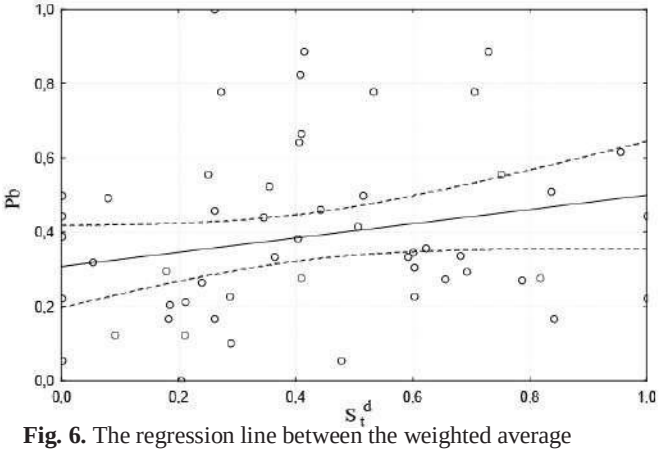

Fig. 6. The regression line between the weighted average normalized values of lead and total sulfur

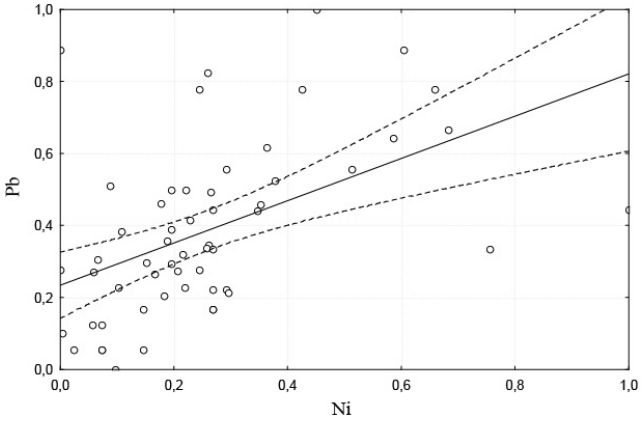

Fig. 7. Regression line between weighted average normalized values of lead and nickel content.

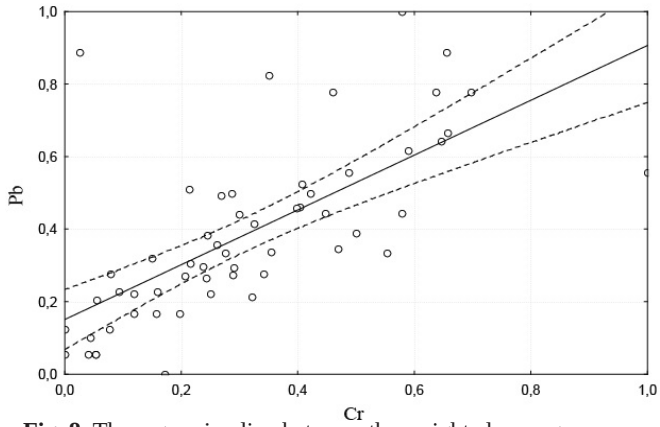

Fig. 8. The regression line between the weighted average normalized values of lead and chromium

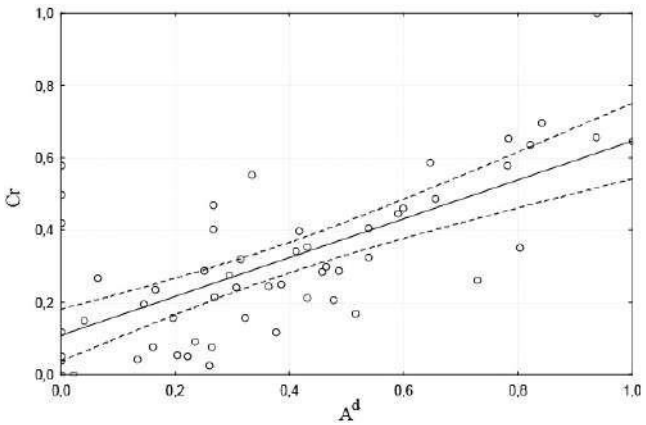

Fig. 9. Regression line between the weighted average normalized value of chromium content and ash content of coal

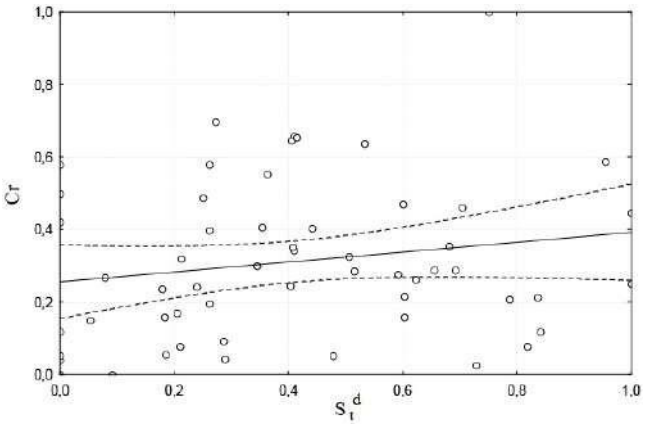

Fig. 10. The regression line between the weighted average normalized values of chromium and total sulfur

Conclusions. Based on the obtained results, we can assume that the main factors controlling the accumulation of nickel, lead and chromium in the coal of the region, in the process of formation of neighboring seams and subsequent transformation of the coal seam changed significantly, and the integrated influence of these factors on the concentration of these elements in coal seams was greatest for seams of suites C_2^4 and C_2^6. For the purpose of establishing the main factors controlling the accumulation of nickel, lead and chromium in the coal seams of the area, correlation and regression analyses of their content with the main technological parameters, as well as the petrographic composition of coal were performed. For the Donetsk-Makiivka geological and industrial district it is established that:

- There is a statistically significant increase in the content of nickel, lead and chromium in local areas of coal seams with immediate siltstone-argillite bedrock and argillite overlying bed (for example, sections of

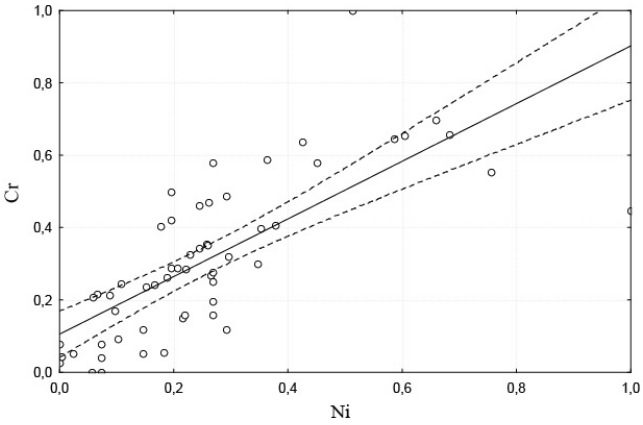

Fig. 11. Regression line between weighted average normalized values of chromium and nickel content.

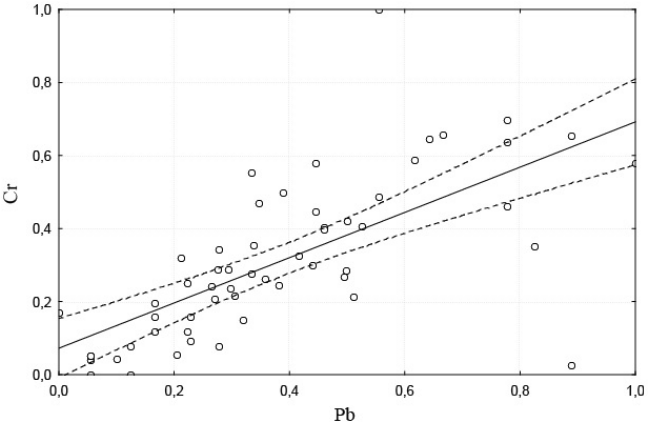

Fig. 12. The regression line between the weighted average normalized values of chromium and lead

seams l_1 and $l_1^1$of the field of the mine «Proletarska Glyboka», seam h_3 of the field of the mine named after Gorkii, seam k_7 of field of the mine named after Rumyantsev , seam h_{10} of the fields of the mines «60 years of Soviet Ukraine» and named after «M.I. Kalinin», etc.);

- There is no statistically significant relationship between nickel and chromium concentrations and total sulfur in contrast to lead, while in some coal seams and their areas with abnormally high concentrations such a relationship is established (example of seams i_2^1 and k_1).

- In some areas of the studied seams (using the method of V.A. Chervyakov [17] a significant positive correlation was found between the content of nickel and chromium with the content of gelled microcomponents).

- There is quite a sharp increase in the concentration of nickel, lead and chromium in the coal seams in areas where there is a layer of sapropelite in their upper part (for example seam m_3 of the field of the «Yasynivska Hlyboka» mine, etc.).

- All studied coal seams are characterized by a slight increase in lead content with increasing degree of coal carbonization, complication of the structure of the seams and a decrease in their thickness, increase in the number of intralayer mineralized layers, fracturing and the degree of recoverable coal. When splitting the seams, the enrichment of coal with lead occurs in a pack with less thickness. Thus, seam n_1 of the «Butivska» mine field splits into two independent seams $n_1^в$ and $n_1^н$. In the north-eastern part of the mine's field, more lead enriched the upper low-thickness assise, and in the south-eastern part the lead is concentrated in the lower assise, which has less thickness.

- There is a statistically significant decrease in the concentration of lead in the areas of coal seams that are directly adjacent to the intraformational erosions.

- In general, in the study area, the decrease in the thickness of coal seams is accompanied by an increase in the affinity of lead to the organic component of coal.

- Lead forms a geochemical association with chromium (correlation coefficient 0.39), linear regression equation: Pb = 0.03747 + 0.22927Cr. At the same time, in some areas of the studied seams (using the method (Cherviakov, 1978)) a significant positive correlation of lead concentration with the content of fusenized microcomponents was established, which indicates the presence of sorption form of lead in coal. In areas of low-reduction coal, a sharp increase in lead significantly correlates with an increase in the content of germanium, which proves the presence of its elemental compounds in coal.

- There is a statistically significant relationship of lead content in the coal seams of the area with ash content (correlation coefficient 0.48), linear regression equation: $Pb = 0.2189 + 0.803A^d$

- There is a statistically significant relationship of lead content in the coal seams of the area with the total sulfur content (correlation coefficient 0.59), linear regression equation: $Pb = 0.138 + 0.5963S_{total.}$

- In the stratigraphic section of the seams, the lead content in the coal usually increases in the upper part of the coal seam.

- The relationship between lead concentrations and the lithological composition of coal-bearing rocks is marked by a statistically significant increase in its content in local areas of coal seams with direct siltstone-argillite bedrock and argillite overlying bed.

- The geochemical association of lead with chromium is typomorphic for the coal seams. Their joint accumulation is due to the bituminous nature of the sorbent. The neutral and alkaline environment of the paleobasins of peat accumulation promotes the absorption of lead by phenolic derivatives of lignin, and the acidic environment is unfavourable for this process.

- There is a geochemical association of chromium with cobalt (correlation coefficient - 0.49), lead (correlation coefficient - 0.52), nickel (correlation coefficient - 0.56). Linear regression equations:

$Cr = 0.10 + 0.96 \times Co$,

$Cr = 0.14 + 0.41 \times Pb$,

$Cr = 0.05 + 0.81 \times Ni$.

- There is a geochemical association of nickel with chromium (correlation coefficient - 0.56), cobalt (correlation coefficient - 0.44), lead (correlation coefficient - 0.56). Linear regression equations:

$Ni = 0.15 + 0.36 \times Cr$,

$Ni = 0.15 + 0.57 \times Co$,

$Ni = 0.16 + 0.30 \times Pb$.

- There is a statistically significant relationship of nickel content (correlation coefficient -0.61) and chromium (correlation coefficient - 0.71) with the ash content of coal, linear regression equations:

$Ni = 0.097 + 0.43 \times A^d$,

$Cr = 0.109 + 0.537 \times A^d$.

- The average lead content in coal of only one k_5^1 seam among all the main working seams of the area exceeds the values of maximum permissible concentration in coal.

- The sample size is characterized by an average value of 9±1 g/t of lead. Thus, its average concentration in the coal seams of the area corresponds to the average lead content in the coal deposits of the former USSR - 10 g/t (Kler, 1979). The background concentration is 5.8 g/t. The distribution of the concentration of lead selection in the coal seams of the geological and industrial district by 97% is a combination of two superimposed lognormal distributions. The results of factor analysis and the bimodal character of the sample indicate the polychronic and polygenic character of lead accumulation in the coal seams of the Donetsk-Makiivka geological and industrial district.

Based on the results obtained, the following conclusions can be drawn:

- It was found that the main factors influencing the concentration of nickel, lead and chromium in the stratigraphically closest section of coal seams in the process of coal accumulation and subsequent epigenetic transformations of the coal-bearing strata underwent significant variations.

- It is established that in general in the geological and industrial district there is a slight increase in the concentration of nickel, lead and chromium with increasing degree of coal carbonization, complication of formation and decrease in their thickness, increase in the number of intralayer mineralized layers and coal fractures. The presence of a significant direct statistical dependence of their content with ash content predicts a decrease of their concentration in the process of coal enrichment. Also, a significant direct linear dependence of the concentration of lead with total sulfur content was established in the district, which indicates the presence of a sulfide form of this element in coal.

The main scientific significance of the obtained results is the establishment of the character of distribution and calculation of weighted average concentrations, basic descriptive statistics of nickel, lead and chromium in coal of the main seams and the suites, to identify the composition and character of their typomorphic geochemical associations, as well as to establish the features and regularities of their accumulation in the coal seams of the Donetsk-Makiivka geological and industrial district. The accumulation of these elements in the main coal seams is polygenic and polychronic. Variations in their concentrations in cross-section and area are mainly due to tectonic and facial features of coal-bearing strata, controlling the petrographic composition of coal, hydrodynamic regime of the peat accumulation basin, lithological-facial composition of the immediate and main roof of coal seams and fracturing of coal and rocks that contain them.

The main practical significance of the obtained results is the calculation of the regression equations between the elements that form geochemical associations and establishment of the relationship between their concentration and coal ash content. The calculated regression equations for nickel, lead and chromium will allow their concentration to be predicted in the main working coal seams of the Donetsk-Makiivka geological and industrial district regarding the values of ash content of the coal. And the calculated correlation coefficients will allow us to predict their content in products and wastes of coal beneficiation and to adjust technological schemes of coal enrichment taking into account the content of these elements.

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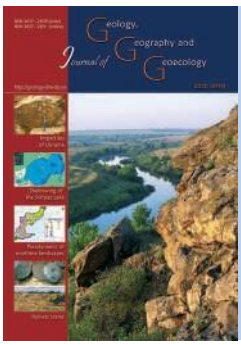

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The aesthetic value of landscapes of the upland right bank area of the Dnieper River of the Kaniv Nature Reserve, Ukraine

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Abstract. The purpose of this publication is to assess the qualities of landscapes that are significant to their aesthetic value. The object of this study is the landscapes of the dislocation loess plateau Ukraine, Cherkasy region, Kaniv district, with a total area of 11.43 km^2. The landscapes of this region have the potential to form expressive and diverse landscapes. Operational units of the study were homogeneous landscapes level areas and tracts with typical appearance, typical for this territory only. The choice of such a research object is explained by the natural and cultural reference of the landscapes of the Kaniv glacial dislocation site. The complexity of landscape-forming processes and the intensity of anthropogenic development of these landscapes led to the emergence of a unique highly attractive image of this territory. The methodological basis of the study, the results of which are presented in this publication, are the starting points of the concept of aesthetic landscape science about the objective factors of aesthetic attractiveness of landscapes that are revealed through a number of physiognomic and compositional parameters of landscapes. We evaluated the aesthetic qualities of the Kaniv landscapes based on a component analysis of «beauty factors». Such significant factors include land features, floral, hydrological, landscape diversity, artificial objects and more. In their sum, «beauty factors» will determine the holistic nature of the visual images of landscapes - landscapes in the perception of landscapes a human. The criteria for assessing the aesthetic qualities of landscapes, in our study, selected their metric parameters, namely: morphological indicators of relief vertical and horizontal dismemberment, aspect and slope of the surface, indicator of landscape diversity - Shannon entropy, forestry. In addition, the floristic diversity of landscapes is analyzed. The physiognomy of the vegetation improves the aspect of the landscapes. Conducting a consistent component analysis of the territory allowed us to determine objective criteria and to calculate the metric indicators of the aesthetic value of the Kaniv dislocation landscapes. The application of the unified aesthetic score scale of aesthetic value indices made it possible to calculate the integral coefficient of aesthetic value of landscapes, which is the sum of the values of the coefficients of significance of the individual metric indicators. According to the results of calculations of the integral coefficient of aesthetic value, the landscapes of the Kaniv right-bank section of the loess plateau are classified as aesthetically valuable.

Keywords: landscape, aesthetic value of the landscape, landscape features, criteria of aesthetic value, «factors of beauty»

Естетична цінність ландшафтів правобережної нагірної ділянки Канівського природного заповідника, Україна

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Анотація. Метою публікації є оцінка якостей ландшафтів, які є значущими для їх естетичної цінності за вибраними критеріями. Об'єктом даного дослідження є ландшафти Канівських дислокацій в межах Канівського району Черкаської області України, з їх потенційною здатністю формувати виразні і різноманітні пейзажі. Операційними одиницями дослідження стали однорідні ландшафтні ділянки місцевостей та урочищ з характерним зовнішнім виглядом, притаманним ландшафтам лише цієї території. Складність ландшафтоформуючих процесів та інтенсивність господарського освоєння цих ландшафтів зумовлює виникнення унікального високоатрактивного образу цієї території. Методологічним базисом дослідження є вихідні положення концепції естетичного ландшафтознавства про об'єктивні фактори естетичної привабливості ландшафтів, що розкриваються через ряд фізіономічних та композиційних параметрів ландшафтів. Оцінка естетичних якостей канівських ландшафтів здійснювалась на основі компонентного аналізу «факторів краси», а саме: особливостей рельєфу, флористичного, гідрологічного, ландшафтного різноманіття, рукотворних об'єктів тощо. Критеріями оцінки естетичної цінності ландшафтів обрані: морфометричні показники рельєфу (вертикальне та горизонтальне розчленування, експозиція та нахил поверхні), показник ландшафтного різноманіття (ентропія Шеннона), показник залісненості. Крім цього проаналізовано флористичне різноманіття, що є значущим для аспектності ландшафтів. Застосування уніфікованої оціночної бальної шкали показників естетичної цінності дозволило обрахувати інтегральний коефіцієнт естетичної цінності ландшафтів, який є сумою значень

коефіцієнтів значущості окремих метричних показників. За результатами розрахунків інтегрального коефіцієнту естетичної цінності ландшафти канівської правобережної нагірної ділянки віднесено до естетично цінних.

Ключові слова: ландшафт, естетична цінність ландшафту, пейзажні властивості, критерії естетичної цінності, «фактори краси»

Introduction. Preserved standard and natural landscapes, biodiversity, balance and environment management in the territories determine the beauty and aesthetic appeal of landscapes, thus increasing their value. Public awareness of the threats of depletion and irrenewability of resources, as well as reducing the possibility of natural self-restoration of geoecosystems, and thus the loss of cultural or natural identity and uniqueness, that forces to reconsider the existing principles of human interaction with nature and find updated approaches of natural resource management. The ecologization of human thinking and behavior is increased by the formation of involvement in the conservation of such special areas (Bauer, 2009; Howley, 2011). The existing concept of ecosystem services considers landscapes as a type of natural capital that ensures harmonious and balanced development and life quality of man and society as a whole (KPMG, 2012). Ecosystem goods and services are understood as the whole spectrum of "goods" and "services" provided by nature. The group of goods (KPMG, 2012) includes non-renewable goods – rocks, minerals, fossil fuels and those that are renewable – animals, plants, water, air, soil, recreation, aesthetics. According to the current classification (Millennium Ecosystem Assessment, 2005, Schirpke, 2016), services provided by ecosystems belong to one of four broad categories that define the functions of natural capital. Among ecosystem services, those that directly affect people are significant, for example, provisioning, regulating and cultural services. Thus, cultural ecosystem services include intangible, provided by ecosystems, which are important in the processes of human cognition of the environment to meet its aesthetic needs, for physical and spiritual growth. These are theresources of the natural and cultural heritage of the regions, the landscapes that form aesthetic scenery, the unique cultural landscapes that are used by human for the purpose of recreation, treatment, rehabilitation. Areas that have landscape-aesthetic resources are not only useful for people, they also significantly contribute to the attractiveness of the region and are correlated with the financial benefits for the development of the region.

The perception of beauty, the picturesqueness of natural or anthropogenic landscapes, has always been a natural process for human, according to the fact that contemplation of the aesthetic is one of the needs necessary for his or her quality of life and productive work. The need for beauty is one of the strongest manifestations of the inner world of human. The beauty, the aesthetics of the environment is a powerful factor that affects psychophysical states and well-being and has a significant impact on a human behavior.

In recent decades, the role of assessments of the aesthetic potential of territories in the optimization of spatial planning decisions, improvement of settlements, for its recreational use has increased. The study and assessment of landscapes is important in the planning and organization of recreation, rehabilitation and treatment. The aesthetics of the environment is associated with the concepts of quality and comfort of human life and work, with the preservation of the quality of the natural environment.

The purpose of this publication is to assess such qualities of the landscapes of the right-bank upland area of the Kaniv Nature Reserve, which are important for determining their aesthetic value.

The object of this study are the landscapes of the dislocated forest plateau in the Kaniv district of Cherkasy region of Ukraine with the total land area of 11.43 km^2, with their potential ability to form aesthetically expressive and diverse landscapes. As operational units, we studied homogeneous landscape features (areas and tracts) with the typical appearance of the landscapes of this area only. The choice of this object is explained by the standard landscapes of the Kaniv land of the dislocated loess plateau. The complexity of landscape-forming processes and the intensity of economic development of the landscapes of this area has led to the emergence of unique highly attractive images. One of such images, called "Tarasovi Obrii" ("Taras' Horizons"), is formed by landscapes from Chernecha Hora (Kaniv) and is considered as a visiting card of Kaniv Region, along with the landscape of Tarasova Hora and the Dnieper River.

The works of Ukrainian researchers, in particular, O. Golubtsov, S. Konyakin, P. Shyshchenko, Y. Shchur, M. Chornyi, L. Chorna, V. Chekhniy are dedicated to research of landscapes of Kaniv land, study of issues of their standarts, preservation of landscape and biological diversity, substantiation of schemes of ecological network of the region.

The interest to the problems of nature and genesis of landscapes of the Kaniv dislocated loess plateau has been developed in the research of many Ukrainian

scientists, physicists, geologists, geomorphologists, biologists, geobotanists, including V. Riznichenko, M. Shcherban, Y. Grubrin, E. Palienko. V. Shevchyk, L. Bakalina, etc. In particular, the works of P. Shishchenko, Y. Shchur, S. Konyakin present the landscape-typological scheme and the results of landscape-morphological analysis of the territory of Kaniv Nature Reserve. Later, in the works of O. Golubtsov and M. Chorny, the results of the study of the landscape structure of the Cherkasy region were presented and landscape optimization schemes of the territory of the Kaniv Biosphere Reserve were developed.

Studies of the beauty of the landscape, its aesthetic qualities and factors that determine the attractiveness, were revealed in the publications of a wide range of researchers. In particular, in the works of D. Linton, G. Buchko, I. Barčáková, V. Nikolaev, D. Dirin, I. Brook, M. Grodzinsky, O. Grodzinska, theoretical and methodological issues of landscape aesthetics are laid down.

Problematic issues of aesthetic assessment in the perception of landscapes have been studied both in the works of these authors and in the studies of K. Eringis, A. Budryunas, Y. Vedenin, L. Filipovich, E. Real, C. Arce, J.M. Sabucedo, B. Kochurova, NV Buchatska, S. Frank et al., U. Schirpke et al., J. Lieskovský et al.

Problematic issues of aesthetic perception of landscapes, the formation of preferences of subjects of perception and their judgments about the beauty of the landscape are considered in the works of R. Kaplan, S. Kaplan, D. Gold, S. Bourassa, N. Bauer et al., D. Gruehn, W. Nohl.

The issue of landscape heritage conservation and ecosystem services in protected areas was studied by V. Stetsiuk, P. Howley, S. Swaffield, W. McWilliam, T. Plieninger et al. Issues of attractiveness and aesthetics of the landscape in spatial and landscape planning were touched upon in the works of V. Stauskas, D. Stefunkova, E. Real et al., A. Jorgensen, L. Szücset et al, O.G. Golubtsov et al.

Materials and methods of research. The methodological basis of this study is the starting points of the concept of aesthetic landscape science on the objective factors of aesthetic attractiveness of landscapes (Linton, 1968; Barčáková, 2001; Dirin, 2005; Frank et al., 2013; Erignis, Budrunas, 1971, 1975), which are revealed through a number of physiognomic and compositional parameters of landscapes. Such important factors include features of terrain, floristic, hydrological, landscape diversity, man-made objects, etc. In sum, "beauty factors" will determine the holistic visual prints of landscapes – sceneries in the perception of landscapes by a human (Kaplan 1989; Grodzinsky, 2005; V. Nikolaev 2003, 2013) and others.

It should be noted that the analysis of only objective factors forming the beauty of landscapes without taking into account the judgments of the subjects of the environment aesthetic perception limits the understanding of the true beauty of landscapes, determining people's preferences and making decisions about the aesthetics of landscapes. However, identifying and evaluating the objective factors of landscape beauty, based on their nature and cultural context of formation, gives reason to understand that a man himself invests in understanding of the landscape aesthetic, and what physical features and traits are decisive in forming its beauty.

The integrity of the visual imprints of landscapes (sceneries) is expressed in sensory perception through their aesthetic qualities: harmony, beauty, contrast, depth, mystery, majesty, intelligibility, diversity, expressiveness, and others. Aesthetic qualities of landscapes are estimated at sensory perception mostly by visual parameters of landscapes (Kaplan, 1989; Nikolaev 2003, 2013; Grodzinsky, 2005). Thus, the aesthetic value of the landscape is manifested through the scenery, which cause the subjects of perception of admiration and positive emotions. In works on aesthetic landscape science it is emphasized that landscapes of a certain territory are a physical basis of a view and in scene all internal communications and properties of a landscape are transferred (Dirin, 2005; Kochurov, Buchatskaya, 2007; Nikolaev, 2003, 2013; Grodzinsky, 2005). The view, as a reflection of the landscape, is also morphologically structured (diverse/monotonous) and has a spatial (compositional) structure. When perceived, scenes are able to form (diverse/monotonous) landscapes, which will determine their aesthetic visual properties: expressiveness, diversity, etc. Landscape properties, as aesthetically valuable, are transmitted by a set of sensory impressions from perceived landscape images (Kochurov, Buchatskaya, 2007). So far component studies of the aesthetics of landscapes have revealed that the active «beauty factors» that affect the beauty and scenery of landscapes include surface terrain, vegetation, hydrological features, diversity, and man-made objects.

Metric indicators of landscape properties, as aesthetically valuable, in such studies are selected those that determine its physiognomic and compositional properties: horizontal and vertical fragmentations of terrain, surface slope, depth of perspective, the degree of mosaic and diversity of landscapes and the degree of forestation. (Eringis, Budryunas, 1971, 1975; Vedenin, Filipovich, 1975; Barčáková et al., 2001; Jaman, Pavlenko, 2010; Frank et al., 2013; Schirpke et al. 2016; Lieskovský et al. 2017). In this study, the

assessment of the aesthetic qualities of the landscapes of the right-bank upland section of the Kaniv Reserve was carried out on the basis of a component analysis of «beauty factors». Morphometric indicators of surface relief, in particular, vertical and horizontal fragmentation, exposure and steepness of the slope, were chosen as criteria for assessing the aesthetic qualities of landscapes. Significant criteria are indicators of landscape diversity (Shannon's entropy) and afforestation. The determined morphological indicators were calculated by mathematical and cartographic methods using the analytical capabilities of GIS. Noting that the assessment of the aesthetic value of landscapes is integral, metrics of landscape properties as aesthetically valuable should be analyzed in parallel with the assessment of such qualitative parameters of landscapes that characterize the sensory perception of scenery: the presence of compositional dominance, multiplicity, aspect presence, etc. Such qualitative parameters of aesthetic evaluation are quite subjective and therefore should be evaluated according to a separate method.

At this stage of the study of the aesthetic value of landscapes, only the objective parameters of the beauty of landscapes are evaluated, which are significant for the qualitative parameters of aesthetic value. Some qualitative parameters were described, in particular aspect, contrast, naturalness, but it was not their influence on the overall assessment that was determined, but their dependence on the surface morphology, the nature of the vegetation, the steepness of the slopes, the number of anthropogenic objects, etc.

The integrated indicator of the aesthetic value of the landscapes of the right-bank upland area of the Kaniv Nature Reserve was calculated in this study by metric indicators of landscapes and consisted of the sum of estimates of individual criteria of aesthetics. During unification of metric indicators of aesthetic value of landscapes when drawing up of an estimation scale, the methodical experience is used, which is covered in previous researches of K.I. Eringis, A.R. Budryunas (Eringis, Budryunas, 1975), Yu.A. Vedenin, L.S. Filipovich (Vedenin, Filipovich, 1975), M. Yu. Frolova (Frolova, 1994), Zh.I. Buchko (Buchko, 1997), D.O. Dirin (Dirin, 2005), B.I. Kochurov, N. V. Buchatskaya (Kochurov, Buchatskaya, 2007), M.O. Dgaman, T.N. Pavlenko (Dgaman, Pavlenko, 2010). To evaluate the aesthetic value of the landscapes of the right-bank upland area of the Kaniv Nature Reserve, the authors determined a score scale for assessing individual criteria of their aesthetic value, which is presented in the Table 1.

Results and analysis. Using practical experience with visual images of the landscapes of the Kaniv Nature Reserve, the authors selected active "beauty factors" and their objective criteria for assessing the aesthetic qualities of the landscapes of this area. On the basis of computer processing of geographical data obtained for many years of experience in the Kaniv Nature Reserve, the restored landscape structure was analyzed, the morphometric indicators of the terrain, forest cover indicators and the diversity of landscapes of the study area were calculated. GEO-data processing was performed using standard tools of ArcGIS modules, in particular, Spatial Analyst, 3D Analyst, Analysis Tools. The initial data for the work on the restored landscape structure and the organization of GEO-data in the form of a Database were opened topographic survey materials (scales 1: 50 000, 1: 100 000, 1: 200 000), remote sensing data for the study area (SRTM 1 Arc-Second) 30m) (NASA), soil maps (scales 1: 200 000, 1:10 000), geological maps, schemes and diagrams of geomorphological structure of different scales, forest management schemes, etc. Computer processing of GEO-data took place in order to inventory the existing natural information on the geodatabase is based on a relational model of GEO-data, which is a two-dimensional table containing information about landscapes (rank of the tract): sediments, soils, vegetation type, nature management and a number of morphometric indicators, map of the restored landscape structure of the studied area which became the basis for determining the integrated indicator of aesthetic value of landscapes according to their objective factors of aesthetic attractiveness of landscapes.

Table 1. Score scale for assessing metric indicators of aesthetic value of landscapes

Criteria **Grade**	**1**	**2**	**3**
indicator of horizontal fragmentation of the surface, km/km^2	<0,5…3	0,5-1…2-3	1-2
indicator of vertical fragmentation of the surface, m	<100	100-200	> 200
forestation, %	>60	<30 absent	30-60
measure of Shannon's entropy landscape diversity	< -560	-560 - -490	> -490
the magnitude of the predominant slopes of the surface, °	<3°	3°-12°	12°-20°…>20°

Source: made by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data

The structure and texture of the terrain in a number of inherent parameters (height difference, exposure and steepness of the slopes, the presence of gullies and arroyos, morphosculptures) is considered to be one of the "beauty factors" of the landscape. The surface relief influences such characteristics of landscape aesthetics as: frequency of scenery changes, mosaicism, nature of landscape drawing, panorama, availability of scenery openings, depth of perspective, breadth of scenery perception angles, presence of visual dominants, etc. Such parameter as the exposure of slopes affects the illumination of a hilly lowland with absolute heights of 200-250 m with a developed erosion network (Palienko, Moroz, Kudelya, 1971; Riznychenko, 1924; Grubrin, 1976) and is called Kaniv Mountains. A fragment of the physical surface of the study area, built on the basis of the digital terrain model (Digital Elevation Model - SRTM 1 Arc-Second (30m)) (NASA), is shown in the Figure 1.

The study area is characterized by a predominance of inclined surfaces and the Figure 2 shows the differentiation of the surface of the study area by the angle of inclination of the surface (fragment).

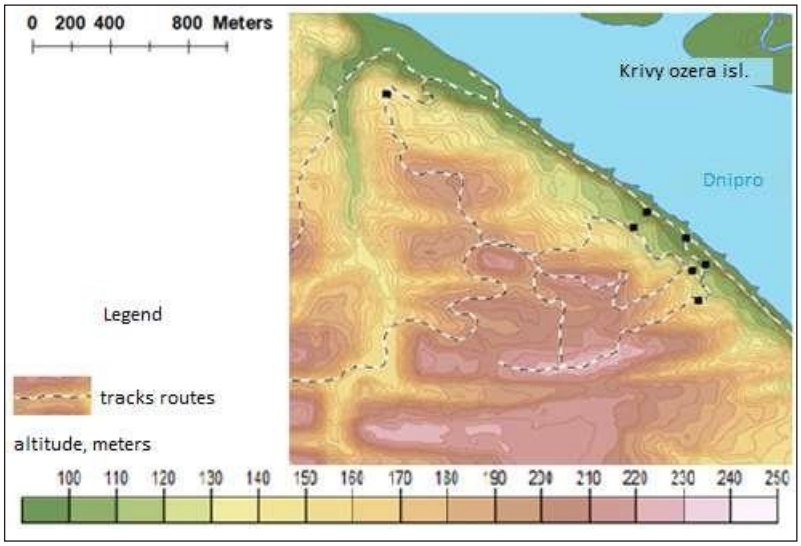

Fig. 1 Physical surface of the right-bank section of the Kaniv Nature Reserve (fragment).
Source: done by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data

landscapes, the type of vegetation and, accordingly, determines a number of visual qualities of the landscape. The presence of slopes, their shape and steepness, affects such characteristics of landscapes as the frequency of landscape changes and versatility. Amplitudes of heights, vertical fragmentation of a terrain form presence of points of landscape opening in the environment, existence of panoramas, visual dominants, depth of perspective, contrast, etc. Morphometric indicators of surface relief can both increase and decrease the quality of landscapes. For example, a slight dissection of the terrain, the predominance of leveled surfaces can lead to monotony of landscapes, lack of variety of plans and panoramas, which, in turn, affects the judgments of the subjects of perception of the aesthetic appeal of a landscape. The research of natural conditions of the study area showed that the right-bank upland area of the Kaniv Nature Reserve belongs to the dislocated loess plateau. The depth of fragmentation of dislocated areas in some places exceeds 100-150 m. In the studies of physiographists and geomorphologists, this area is

The results of morphometric analysis of the digital terrain model of the study area (presented in the Table 2) show the predominance of sloping surfaces of different steepness, which are formed as a result of the long history of Kaniv dislocations. Sloping and slightly sloping hillsides are dominated by 40.9%, which are confined to the watersheds of ridges and inter-ridge lowering of the dislocated plateau, forming a wavy surface relief. 35.7% of steep and precipitous slopes add the expressiveness to the landscape, which are typical for erosion-landslide areas of ancient anthropogenic landslides confined to circuses and modern gullies, creating a variety of attractive transitions from one landform to another. Slightly sloping areas make up a smaller share of the study area of 23.4% and are visually contrasting in relation to the surrounding areas.

GIS analysis of DEM on the exposure of the surface of the right-bank upland area of the Kaniv Nature Reserve (orientation of the slopes on the sides of the horizon) indicates the predominance of the surfaces of the northern and eastern exposures. Generaliza-

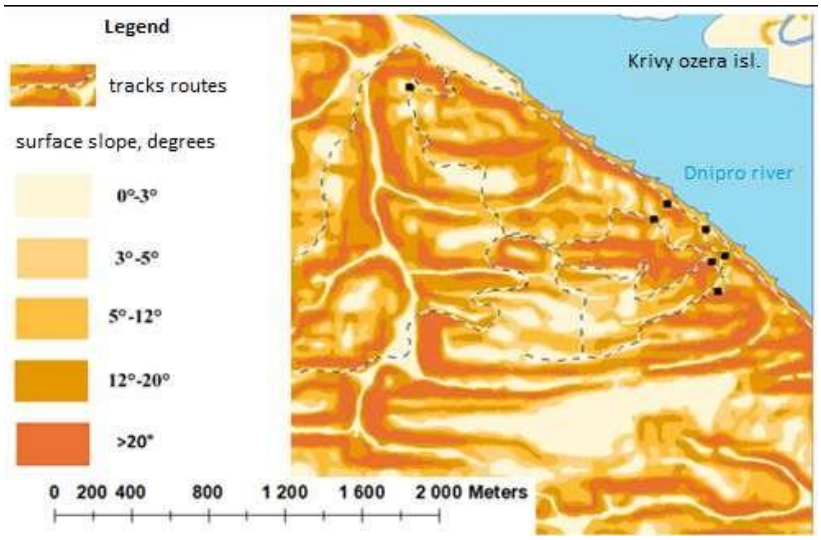

Fig. 2 Steepness of the slopes of the right-bank section of the Kaniv Nature Reserve (fragment). *Source: done by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data*

tion of the results of landscape analysis (GIS-based analysis) by the number and share of landscape tracts by surface exposure for this area are presented in the Table 3, and the Figure 3 shows the differentiation of the study area (fragment) by surface exposure in main directions – north, west, south, and east.

In our case, the predominance of the surfaces of the northern and eastern exposures determines the disclosure of multifaceted landscape views of the left-bank landscapes of the Dnieper Valley from observation points along the edges of the slopes of the plateau of the northern and north-eastern exposures.

Table 2. Quantitative distribution of surfaces according to the slope steepness for the Kaniv right-bank upland area

Surface character: angle of inclination, °	Square, m²	% of the total area
leveled and slightly inclined surfaces <3°	2 671 542	23.4
gentle slopes 3°-6°	1 690 600	14.8
slightly sloping hillsides 6°-12°	2 987 251	26.1
precipitous slopes 12 ° - 20 °	2 600 534	22.7
steep slopes >20°	1 484 715	13.0
∑	**11 434 642**	**100**

Source: done by the authors based capability on the analytical capabilities of GIS in spatial analysis of geographical data

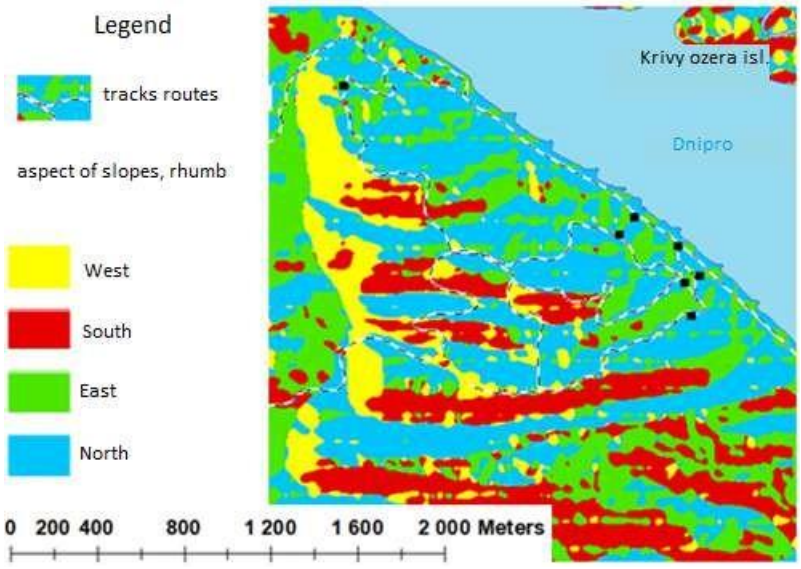

Fig. 3 Exposition of the slopes of the right-bank section of the Kaniv Nature Reserve (fragment). *Source: done by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data*

Table 3. Distribution of landscape tracts by exposure of slopes for the right-bank upland area of the Natural Reserve

Rhumb	Degrees	Quantity	Share, %
north	315 – 45	391 630	31.15635
east	45 – 135	336 287	26.7535
south	135 – 225	304 795	24.24814
west	225 – 315	224 271	17.84201

Source: done by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data

In addition, the northern and eastern exposures are important (the amount of solar radiation received by the surface – insolation) in the formation of the type of vegetation – fresh oak-hornbeams, which also form a distinct multifaceted landscape, especially in spring and autumn.

During the study, in order to determine the aesthetic value of the landscapes of the study area, other morphometric indicators of relief were calculated (their values are summarized in the Table 4), which have an impact not only on the formation of landscape diversity, but also on other landscape qualities of landscapes.

Table 4. Morphometric indicators of the terrain and its values for the territory of Kaniv right-bank upland area

Morphometric indicators of the terrain	Value
max elevation mark, m	254
min elevation mark, m	79
vertical fragmentation of the terrain, m	175
length of thalwegs (valley lines), km	33.601
horizontal fragmentation of the terrain km/km^2	2.94

Source: done by the authors based on the analytical capabilities of GIS in spatial analysis of geographical data

The results of a number of applied studies on aesthetic assessments of territories prove the direct dependence of visual aesthetic perception of the surrounding landscape on the nature of surface morphology, namely the location of the point from which the landscape views (Nikolaev 2003, 2013; Dirin, 2005; Kochurov, Buchatskaya, 2007). Visual perception requires a distance between the subjects of perception and landscapes. And such distance is provided by the location of the point of view, which in turn determines a greater or lesser perspective, foresight, versatility of the landscape. Scenery points and landscapes are connected. Even minor changes in the position of the viewpoint lead to a change in the landscape. Observation points also provide a view, the depth of the landscape perspective, the number of plans, etc. Thus, the location of the point itself plays a significant role. Thus, its location on elevated areas provides a broad overview, landscape perspective. The breadth of the view is also influenced by the nature of the ratio of the relief to the silhouette of the forest canopy (Nikolaev, 2003, 2013; Vedenin, Filipovich, 1975). Vertical fragmentation of the surface, linear stretching of the dislocated plateau, meadow-steppe vegetation on the watersheds provides high indicators of saturation of the opening points of the landscapes of the Kaniv upland area. On the deforested ridges, the edges of the forested watershed slopes of the Kaniv dislocations natural observation decks are located, which offer highly attractive landscapes with rich plans, far-sighted with a deep perspective. For example, from the tops of the Mar`yina, Knyazha, Pylypenkova, and Lysa mountains, panoramic views of the hills of the dislocated loess terrace (north-northeast) and the hilly loess-moraine plain (south-southwest) open up. To the north of the Chernecha, Pylypenkova, and Lysa mountains, wide multifaceted landscapes open up to the city of Kaniv, the Trakhtemyriv Peninsula, and the Kaniv Reservoir, so on. To the north of Mar`yina Hora are the steep slopes of the Great and Small Scythian Horodyshche, which are the monuments of archaeological heritage. From the natural observation deck on Velyke Horodyshche there is a far-sighted panorama of the left-bank landscapes of the first floodplain terrace (covered with pine forests) and wide floodplain of the Dnieper, crossed by numerous old rivers strait, floodplain lakes and the floodplain islands of Kr**i**vy ozera, Shelestiv and Kruhlyk.

The assessment of the landscape properties of Kaniv scenery will also depend entirely on the metric characteristics of the landscape diversity of the territory, which requires an analysis of its landscape structure. Indicators of landscape and floral diversity determine the visual changes in landscapes, changes in physiognomic parameters, the alternation of different landscapes, the presence of several plans, and others. (Nikolaev, 2003, 2013; Dirin, 2005; Eringis, Budryunas, 1971, 1975; Vedenin, Filipovich, 1975, etc.). As the part of this study, we calculated the Shannon

Landscape Diversity Index to determine the extent of landscape diversity. In our case, some information indicator of the degree of inventory diversity or an indicator of the complexity of the territorial structure is calculated according to the Shannon's formula. Thus, the indicator of the complexity of the territorial structure (the total number of different landscape units

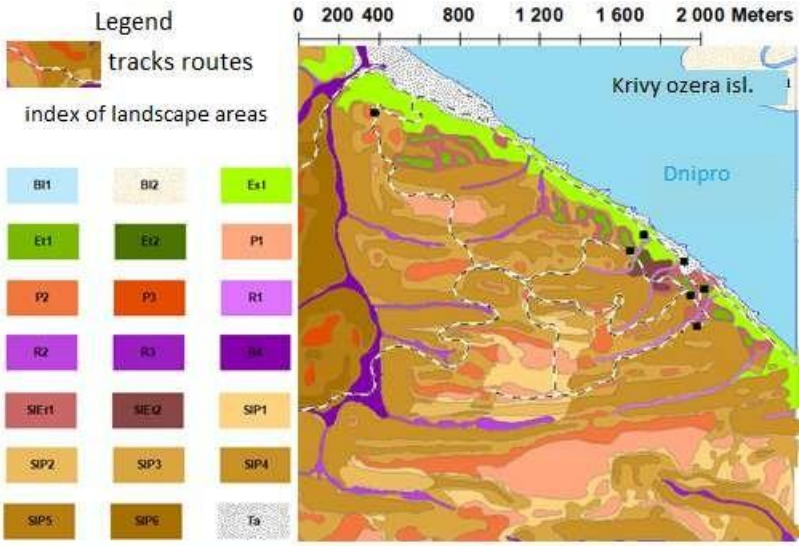

Fig. 4 Fragment of the map of the restored landscapes of the right-bank section of the Kaniv Nature Reserve (for an explanation of the indices, see the Table 5 below)
Source: done by the authors based of the analytical capability of morphological analysis of landscapes

within the study area) is calculated (-322.48), which determines the considerable landscape diversity.

The landscape diversity of the Kaniv Mountains is formed by the simultaneous action of a set of factors, among which the terrain and geological substrate are the most active ones. The geological and geomorphological structure of the studied area directly determines: the differentiation of microclimatic and hydrological indicators of the territory, differences in the spatial structure of the soil cover, which, in turn, affects the diversity and structure of ecotypes. Also, an active factor influencing the landscape diversity in the studied area is anthropogenic. The long history of intensive anthropogenic development of the Dnieper region of Kaniv has led to the practical destruction of the original forest-steppe landscapes. The deforestation of primitive oak forests, which lasted until the beginning of the XX century, led to the intensive development of erosion and geodynamic processes, which stimulated the formation of an extensive ravine-beam network and caused a change in much of the forest landscape on meadow-steppe. The extensive ravine-beam network of the territory of Dnieper region of Kaniv has led to a radical change in the image of local landscapes. Withdrawal of territories from agricultural use and formation of secondary stands in the postwar years stimulated the processes of secondary restoration of native landscapes, which allowed us to warn today about the gradual change in the landscape structure of the studied area. The landscape diversity of the studied area reflects the peculiarities of the historical development of Kaniv and reveals the combined effect of the main landscape-forming factors. Figure 4 shows the fragment of the map of the restored landscapes of the study area.

Landscape representativeness of Kaniv district of Cherkasy region, according to previous landscape-typological studies, consists of complexes: deciduous-forest, forest-steppe, meadow-steppe, mixed-forest coniferous, meadow and swamp types (Golubtsov and Chorny, 2014; Dmitruk, Romanchuk, 2002). Intrazonal ravine-beam and valley-river landscape complexes are also common here. During the landscape morphological analysis and landscape mapping of the studied area, the authors identified 71 homogeneous landscape areas (tract level), which are combined into 21 landscape areas. The Table 5 presents an abbreviated description of the landscape areas of the right-bank section of the Kaniv Nature Reserve.

Characterizing landscape qualities as signs of aesthetic value of Kaniv Mountains landscapes should not be limited to the analysis of landscape structure or the nature of the terrain surface (Linton, 1968; Eringis, Budrunas 1971, 1975; Vedenin, Filipovich, 1975; Barčáková, 2001; Barčáková, 2001; 2013; Dirin, 2005; Frank et.al., 2013; Howley, 2013, etc.). Relevant information on the biological indicators of the aesthetic value of landscapes can be obtained based on the results of the field geobotanical research.

Table 5. Description of landscape areas for the map of restored landscapes of Kaniv right-bank upland area

Index	Description of the areas
P1	ridge-hilly undulating well-drained watersheds of loess height with sod podzolic soils at the outcrops of Cretaceous sandstones overlain by sands on the tops in complexes with slightly inclined inter-ridge lowerings with gray podzolic loess soils and soils
P2	ridge-hilly undulating well-drained watersheds of loess height with sod podzolic soils at the outcrops of Cretaceous sandstones overlain by sands on the tops in complexes with slightly inclined inter-ridge lowerings with gray podzolic soils under the loess sediments in the oak-hornbeam forests
P3	undulating hills of well-drained watersheds of the ancient alluvial-terraced plain with sod podzolic sandy-gravelly soils on the outcrops of sandy deposits of the lower anthropogen lined with Cenomanian sandstones under dry pine forest and acacias in alternation with oak-hornbeam forests
Et1	pseudoterasses of early anthropogenic erosion-landslide circuses with gray podzolic soils on loess under oaks and hornbeams and cultivated garden vegetation
Et2	pseudoterasses of early anthropogenic erosion-landslide circuses with sod podzolic sandy-gravelly soils on wedges of sandy deposits of the lower anthropogen lined with Cenomanian sandstones under dry pine trees
Esl	erosion-landslide slopes of early anthropogenic pseudoterasses under oaks and hornbeams (sometimes with cultivated vegetation)
SlEt1	slopes of pseudo-terraces of early anthropogenic erosion-landslide circuses with gray podzolic soils on loess under oaks and hornbeams (sometimes with cultural garden vegetation)
SlEt2	slopes of pseudoterasses of ancient anthropogenic erosion-landslide circuses with sod podzolic sandy-gravelly soils on wedges of sandy deposits of the lower anthropogen lined with Cenomanian sandstones under dry pine forests
SlP1	sloping and slightly sloping hillsides of ridge-hilly undulating and hilly well-drained watersheds with sod podzolized soils at the outcrops of Cretaceous sandstones overlain with Cenomanian sands on the tops and weakly sloping well-drained inter-ridge lowerings with gray podzolic soils in forests under meadow-steppe plant formations
SlP2	precipitous and steep slopes of ridge-hilly undulating and hilly well-drained watersheds with sod podzolized soils at the outlets of Cretaceous sandstones overlain by Cenomanian sands on the tops and slightly sloping well-drained clear-ridged lowerings with gray and light gray podzolic soils on loess under meadow-steppe plant formations
SlP3	steep and slightly sloping slopes of ridge-hilly undulating well-drained watersheds with sod podzolic soils at the outlets of Cretaceous sandstones overlain by Cenomanian sands on the tops and weakly sloping well-drained inter-ridge lowerings on gravel ridges
SlP4	steep and precipitous slopes of ridge-hilly wavy well-drained watersheds with sod podzolized gravelly soils at the outlets of Cretaceous sandstones overlain by Cenomanian sands on the tops and weakly sloping well-drained inter-ridge lowerings of ridges of forest-like
SlP5	precipitous and slightly sloping hillsides of undulating hills of well-drained watersheds of the ancient alluvial-terraced plain with sod-slightly podzolic, sod podzolic sandy-gravelly soils on the outcrops of sandy deposits of the lower anthropogenic subsoil
SlP6	steep and precipitous slopes of undulating hills of well-drained watersheds of the ancient alluvial-terrace plain with sod podzolic sandy-gravelly soils on the outcrops of sandy deposits of the lower anthropogen lined with Cenomanian sandstones under alternate gravels and dry pine forest and acacias in alternation with oak-hornbeam forests
Bl1	sandy-silty bottom of the Dnieper and silty-sandy bottoms of the Dnieper riverbeds with plant formations of aqual river complexes
Bl2	sand channel floodplains with initial soil formation with willow and grass-sedge weeds and slightly undulating sloping reduced periodically flooded plains with sod underdeveloped sandy soils under coarse-grass weeds, willow or poplar-black alder plantations and sedge moisture-loving weeds in the coastal strip. The slopes of the areas are gently sloping and sloping with coastal sedge-black alder plantations and sedge weeds
Ta	leveled artificial coastal pseudoterrace on a proluvial plume with washed-out transformed sandy slightly sodden soils under lawns, ornamental plantations, sedges and acacias occupied by road infrastructure and sparse buildings with sloping and slightly sloping hillsides transport infrastructure and road complexes)
R1	narrow, deep ravines in loess soil of sandy-loamy composition with sloping slightly turfed and steep not turfed slopes often with outcrops of rocks with sod gleyed soils on the bottoms on deluvial loams of medium and heavy-loamy composition under gravel vegetation
R2	complexes of narrow, deep branched ravines in loess rocks with flat extensions with sloping slightly turfed and rocky outcrops of slopes with sod gleyed and gleyed soils along the bottoms on medium-heavy composition of deluvial loams under hornbeam vegetation
R3	wide, deep ravines and gullies in loess soil of loamy composition with sloping slightly turfed and steep non-turfed slopes often with rock outcrops with sod gleyed and gleyed soils on the bottoms on medium-heavy composition of deluvial loams under vegetation of hornbeam groves with sod gleyed hard loam soils on deluvial-proluvial deposits under moisture-loving weeds and black alders
R4	wide, shallow ravines and beams in sandy rocks with flat extensions with sloping and slightly sloping hillsides with sod sandy-loamy soils on the outcrops of sandy late anthropogenic sediments lined with Cenomanian sandstones with sandstones rocks slightly sloping with sod sandy loam soils under forests and shrubs, moisture-loving vegetation

Source: done by the authors based of the analytical capability of morphological analysis of landscapes

Thus, botanical and phenological descriptions of vegetation, in particular, changes in their physiognomy/ aspect presence, allow us to record the change in the visual characteristics of individual landscapes during the seasons (Shevchyk, 2012). In the future, this allows us to study the aspect of landscapes, as the aesthetic quality of landscapes. An abbreviated list of aspecting grassy species of the right-bank upland area of the Kaniv Nature Reserve, which especially affect the physiognomy of its landscapes, can be seen in the Table 6.

The variety of colors of aspecting plant species (trees, shrubs, grasses) of the Kaniv right-bank upland area, especially those that affect the physiognomy of its landscapes in different seasons, is summarized in the Table 7.

The Figure 5 shows the chart of color distribution of aspecting plant species by months of the year. The distribution indicates that the flora of Kaniv dislocations in summer, autumn and spring is characterized by the most expressive physiognomy. Such a rich aspect is aesthetically valuable for such natural landscapes as the landscapes of the Kaniv right-bank upland area.

Local meadow-steppe plant formations of the right-bank upland area of the Kaniv Nature Reserve are characterized by a pronounced feature of phenological changes in the aspects of vegetation in connection with the successive flowering of bulbs, cereals and grasses. Peculiar accents or landscape dominants that diversify the landscapes of these areas are shrub species represented by steppe cherry *Prunus fruticosa Pall.*, *Thorn Prunus spinosa L.*, dog rose *Rosa canina L.*, hawthorn *Crataegus pseudokyrtostyla Kud.* Different types of deciduous forests of the Kaniv Mountains also change their appearance during the growing season: in winter, spring, summer they look different. In spring, the physiognomy of fresh hornbeam forests of the Kaniv Reserve is determined primarily by the flowering of ephemerals and ephemeroids: snowdrops *Scilia bifolia L.*, snowdrop *Galanthus nivalis L.*, anemone *Anemone nemorosa L.*, *Marshall Persian Corydalis marsh.* and hollow growth of *Corydalis cava L. Schweigg*. et. Short. On the edges there are spreading bushes of flowering thorns Prunus spinosa L., wild apple Malus sylvestris Mill. and pears Pyrus communis L., which creates attractive visual accents.

There are stands for the aesthetic attractiveness and variability of the physiognomy (according to the seasons) of the forests growing in the study area. The stands, with admixtures of various herbaceous and shrubby species, with a distinct seasonal aspect, create separate curtains, thus diversifying the landscape. For example, the heart-shaped linden *Tilia cordata Mill.*, which is sometimes found in the second / third tier of hornbeam forests and everywhere on the Reserve estate, contributes to the diversification of aesthetic impressions. Linden blooms later than other trees, in early summer, and further saturating the air with the aroma of its flowers, complementing the holistic image of the landscape. The multifaceted forests of the right-bank upland area of the reserve are in autumn, before the beginning of November. It is in the autumn season that maples *Acer platanoides L.*, *Acer negundo L.*, hornbeam *Carpinus betulus L.*, rowan *Sorbus aucuparia L.*, birch *Betula pendula Roth.*, Maiden grape Parthenocíssus quinquefolia are added to the landscapes. These wood species are aspected by a wide range of colors from light yellow to reddish-brown. Aesthetically attractive is the change in the characteristics of the aspect from a uniform green to a colorful yellow, red.

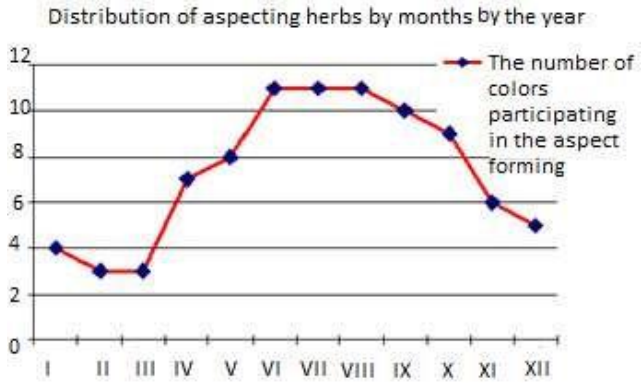

Fig. 5. Aspecting plant species of the Kaniv right-bank upland area of the nature reserve by months by the year.
Source: done by the authors based of the analytical capability of applied geobotanical studies

In addition, the nature of the distribution of vegetation is manifested in the forest afforestation of the territory. Afforestation can both positively and negatively affect the landscape qualities of landscapes. Thus, the optimal values of forest cover are values in the range of 30-60%, according to some studies – 25-

Table 6. Abridged list of aspecting grassy species of the territory of Kaniv right-bank upland area

Latin name of the species	The growing season	Color of aspect
Tragopogon ucrainicum	blossoming: June-September	bright yellow
Dianthas pseadosquarrosus	blossoming: June-October	pale pink
Verbascum phoeniceum	blossoming: May-July	bright violet
Centaurea borysthenica	blossoming: June-August	pink
Genista tinctoria	blossoming: June-July	yellow
Euphorbia seguieriana Neck.	blossoming: May-June, September-October	yellow, greenish-yellow
Campanula persicifolia	blossoming: June-September	violet-blue
Thymus marschallianus	blossoming: June-August	pale pink
Dianthus membranaceus	blossoming: June-October	bright pink, violet
Helichrysum arenarium	blossoming: July-September	yellow
Galium verum	blossoming: June-September	pale yellow, yellow
Verbascum nigrum	blossoming: June-October	bright yellow
Hypericum perforatum	blossoming: June-September	yellow
Salvia pratensis	blossoming: May-September	blue-violet
Achillea millefolium	blossoming: June-October	greenish-white
Euphorbia cyparissias	blossoming: May-June, September-October	yellowish, yellow-green
Potentilla argentea	blossoming: June-September	yellow
Veronica spicata	blossoming: May-August	bright cyan/blue, pink, violet/white
Medicago falcata	blossoming: June-August	yellow
Trifolium pratense	blossoming: May-September	pink, violet-pink
Vicia cracca	blossoming: May-October	light purple
Lathyrus latifolius L	blossoming: June-August	bright pink to red
Lotus ucrainicus	blossoming: June-August	bright yellow
Trifolium arvense	blossoming: May-September	pale pink
Trifolium repens	blossoming: May-September	white, pale pink or pale yellow
Melilotus officinalis	blossoming: June-September	yellow, whitish-green
Campanula patula	blossoming: May-July	lilac
Tanacetum vulgare	blossoming: June-September	bright yellow
Origanum vulgare	blossoming: June-August	pink or dark-pink
Scabiosa ochroleuca L.	blossoming: May-September	pale yellow
Falcaria vulgaris Bernh.	blossoming: May-July	white
Scilla bifolia	blossoming: march-April	blue violet
Melampyrum nemorosum	blossoming: June-August	violet-orange
Corydalis marschalliana	blossoming: march-April	light-yellow or cream
Corydalis cava	blossoming: march-April	from white, cream to purple, purple-violet
Galanthus nivalis	blossoming: march-April	white and green
Anemone nemorosa	blossoming: April-May	white, pale pink
Dentaria bulbifera	blossoming: April-May	white, pale pink
Aegopodium podagraria	blossoming: June-July	white
Galium odoratum	blossoming: May	white
Stellaria holostea	blossoming: April-May	white
Lathyrus vernus	blossoming: April-May	purple, blue
Geum urbanum	blossoming: May-June	yellow
Campanula trachelium	blossoming: May-July	blue and violet
Convallaria majalis	blossoming: May	white
Pulmonaria obscura	blossoming: April-May	pink, violet or blue
Viola mirabilis	blossoming: April-June	violet, pale blue
Allium ursinum	blossoming: April-May	white
Platanthera bifolia	blossoming: June-July	white

Source: done by the authors based of the analytical capability of applied geobotanical studies

50% (Jaman, Pavlenko, 2010). With smaller or larger values of forest cover, the attractiveness of landscapes decreases, as the contrast of landscape changes decreases; with excessive forest cover values, the rate of landscape opening points in landscapes also decreases, even with positive morphometry.

Table 7. Background and complementary aspect colors of plant species of the Kaniv Mountains

Season	Background color	Additional colors
winter	white, black, green	brown
spring	green, brown	white, pink, blue, violet, purple, lilac, cyan, cream, yellow, mauve
summer	green, light yellow, straw	white, pink, blue, violet, purple, lilac, cyan, cream, bright yellow, mauve, red, pale green
autumn	green, brown	yellow, orange, red, blue, purple, brown

Source: done by the authors based of the analytical capability of applied geobotanical studies

According to the calculations during the component analysis, the forest cover of the study area was 75.9%. This value of forest cover is excessive and, in some cases, could reduce the aesthetics of the landscapes of the Kaniv Mountains. However, taking into account the standard of hornbeam-oak forests of the Kaniv Nature Reserve, the natural landscapes of the territory, as well as the nature of the comparison of the relief with the silhouette of the forest canopy, this indicator is positive (Vedenin, Filipovich, 1975).

In determining the aesthetic value of landscapes according to the above objective criteria, it was argued that each of the criteria included in the assessment has an equivalent effect on the formation of landscape aesthetics (Eringis, Budryunas, 1975; Vedenin, Filipovich, 1975; Frolova, 1994; Buchko, 1997); Dirin, 2005; Kochurov, Buchatskaya, 2007; Jaman, Pavlenko, 2010). Thus, the sensitivity coefficients of the scores of each individual indicator were derived by bringing the values of the score to 1, the results of the calculations are presented in the Table 8.

The calculation of the integrated coefficient of aesthetic value k of the landscapes of the right-bank upland section of the Kaniv Nature Reserve is the sum of the values of the coefficients of sensitivity of individual metrics for the landscapes of the studied area:

where, k = 1.5-2.5 – low-value landscapes, k = 2.6-3.5 – valuable landscapes, and k = 3.6-5.0 –high-value landscapes.

Conclusions. The study identified objective criteria for the aesthetic value of the landscapes of the right-bank upland section of the Kaniv Nature Reserve. As a result of the performed landscape-morphological analysis, morphometric analysis of the terrain, analysis of afforestation and analysis of aspecting plant species and seasonal changes of physiognomy of the territory, indicators of aesthetic value of Kaniv Mountains landscapes were calculated. The determined indicators formed the basis for further elucidation of the integral coefficient of aesthetic value of the landscapes of the studied area. The calculated integrated coefficient of aesthetic value showed that the studied landscapes belong to the category of aesthetically valuable (k = 3.4).

The method used to assess the aesthetic appeal of landscapes according to objective criteria is considered as the part of a comprehensive aesthetic assessment of the landscapes of the Kaniv Mountains. Comprehensive aesthetic evaluation should take into account a wider range of active factors that affect the subjective criteria for evaluating aesthetic qualities: expressiveness, beauty, contrast, depth, diversity and others. In particular, hydrological features, anthropogenic (cultural) transformations of landscapes. Identifying and evaluating objective factors of landscape beauty, based on the natural

Table 8. Integral coefficient of aesthetic value of the studied landscapes of Kaniv Nature Reserve

Indicator	Indicator value	Score	The coefficient of significance of the score
indicator of horizontal fragmentation of the surface, km/km^2	2.94	2	0,7
indicator of vertical fragmentation of the surface, m	175	2	0,7
forest cover, %	75.9	1	0,3
the magnitude of the predominant slopes of the surface, °	3°-12°	2	0,7
measure of Shannon's entropy of landscape diversity	-322.5	3	1
Integral coefficient of the aesthetic value of the landscapes, k			**3.4**

Source: done by the authors based of own studies of aesthetic value

and cultural context of their development, gives reason to understand what a person invests exactly in understanding the aesthetic of the landscape, what its physical features and traits are decisive in shaping its beauty.

The study requires further work on a comprehensive methodology for assessing the aesthetic value of landscapes, as the assessment is extremely important to take into account such criteria of landscape beauty, which will depend on subjective factors of attractiveness: cultural value, accessibility, environmental friendliness and others.

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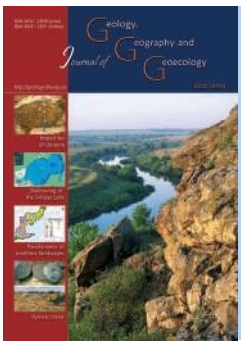

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Ecologism as a Modern Strategy of Human Survival (Regional and Global Dimensions)

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Abstract. The aim of this article is to reveal the ecological education's perspectives at the present stage of the globalization processes' deployment and their influence on the formation of the environmental consciousness of both an individual and the society as a whole. A wide variety of methods were used in the research, in particular, general scientific, special scientific and philosophical methods and approaches, including structural and functional analysis, synthesis, comparative, systemic, as well as synergetic approach, which allowed considering education as a complex and opening system. The authors have proved that the organization of the ecological education is important at all levels of an individual's socialization, especially in the process of enculturation. The individual simultaneously forms responsibility for his or her actions at the local level (within the city, region, or state) as well as on the planetary scale, as the modern humankind faces global ecological problems, which cannot be solved by a separate society. Thus, humankind has already developed appropriate protocols and activity programs, but that is not enough for today. Therefore, the authors of this research claim that only carefully considered approaches to education and upbringing are the ways that enable real solving of the global problems instead of declarative attitude to them. The authors attempted to substantiate the need to organize the environmental education and upbringing at all levels of an individual's socialization in the context of modern globalization processes. The research results can serve as guide marks for improving ecological education, both at the state programs level and at the supranational level.

Keywords: ecology, ecologism, ecological education, upbringing, globalism, global problems of our time

Екологізм як сучасна стратегія виживання людства (регіональний і глобальний вимір)

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Анотація. Висвітленні перспективи екологізму на сучасному етапі розгортання глобалізаційних процесів та їх вплив на формування екологічної свідомості як окремо взятого індивіда, так і людства загалом. У процесі дослідження застосовано різноманітні методи та підходи, а саме структурно-функціональний, аналіз, синтез, порівняльний метод, системний, а також синергетичний підхід. Автори довели, що організація екологічної освіти, а саме визнання в її структурі екологізму (локального і глобального вимірів його існування і розвитку) є важливою на всіх рівнях соціалізації людини, особливо в процесах інкультурації. Індивід одночасно формує відповідальність за свої дії на місцевому рівні (в межах міста, регіону, чи держави), а також на планетарному рівні, оскільки сучасне людство стикається з глобальними екологічними проблемами, які не можуть бути вирішеними окремо взятим суспільством. Людство вже розробило цілу низку відповідних протоколів, програм діяльності, але цього, на сьогодні, недостатньо. Тому автори даного дослідження стверджують, що лише ретельно продумані підходи до навчання та виховання – це ті дієві способи, які дозволять реально вирішувати глобальні проблеми, замість декларативного ставлення до них. Обгрунтовано необхідність організації екологічної освіти та виховання на всіх рівнях соціалізації індивіда в контексті сучасних глобальних перетворень. Результати дослідження можуть слугувати відповідними орієнтирами для покращення екологічної освіти як на державному, так і наднаціональному рівнях.

Ключові слова: екологія, екологізм, екологічна освіта, виховання, глобалізм, глобальні проблеми сучасності

Introduction. The world has become a whole one since the time of great geographical discoveries. However, today it is characterized by the intensive deployment of globalization processes. This period marked the fact that humanity by its activities has influenced the environment more and more and it has far-reaching devastating consequences. This is what poses a direct threat to the human survival today.

Analysis of recent research. Modern scientific and non-fiction literature has a rather powerful basis for research of the state of global problems. These are different programs of local, state or regional level regulations which provide the rational use of natural resources, opportunities for their restoration, or on the contrary, finding alternatives. That also involves developing different long-term andshort-term programs to conserve and restore the natural environment and resources as well as their rational production and use. For example, they are the annual analytical reports of the UNO and other organizations within its membership (FAO, ECE), reports and proposals from non-governmental organizations and associations, such as the Club of Rome, which serves as an advisory body.

Conservation and development of the bio- sphere, namely the issue of regulation and de- velopment of world forest resource potential are considered in many scientific works of native and foreign authors. Among them, it is necessary to pay attention to the works of such scientists as D. Alderman, D. Bauer, E. Pepke, T. Pakhkasalo, M. Foneska and many others.

A number of studies are focused on examining the Earth's population growth rate and the effects of the demographic "outbreaks" in some globe regions. In this aspect, the researches of L. Anderson, J. Blake, K. Davis, S. Enke, J. Caldwell, A. Landry, L. Levi (2017) and others should be mentioned.

The current approach to the study of climate change connected with the ice sheets melting in Antarctica is represented by the work of a group of scientists who use the latest technological computer facilities to predict the effects of global warming. In particular, they are such scientists as B. Bronseler, M. Winton, S. Griffis, V. Yurlin, B. Rogers, O. Serhienko, J. Ronald (2018) and others.

Lara Buchak (the University of California, 2019) uses the method of risk analysis and environmental policy-making while studying the issue of climate change. Oxford University researcher Hilary Greaves (2019) makes a comparative analysis of climate changes, which are directly proportional to the Earth's population growth rates.

The current state of ecological education requires rethinking of the "human-nature" attitude on the principles of eco-biocentrism. These questions are clarified in the works of V. Boreiko (2000), D. Grodzynskyi (2002), T. Gardashuk (2015), V. Krysachenko (2002), M. Kiselov (2018), and others.

The aim of the article is to reveal the essence and prospects of environmental education at the current stage of development of the world community, which is associated with awareness of the paradigm shift from local vision and solving environmental problems to global, large-scale existence of them, possible and necessary ways to overcome them.

The methodology of this research involves a complex analysis of the relationship "human – nature" at the beginning of the XXI century. It is an attempt to actualize this relationship through the processes of upbringing and teaching global eco-consciousness instead of seeing its abstract version.

Presenting main material. It was at the end of the XXth century when the unprecedented load was put on the nature. This is primarily due to the increase in the population of the Earth by more than 4 times. The world population grew from 2.5 billion in 1950 to 6.1 billion in 2000. It is estimated that by 2050 the Earth's population will increase to 9.7 billion (Rusanova, 2007). Currently, the world's population is 7.7 billion people.

The demographic situation in the world has two main peaks. The first is growth, and the second is ag-

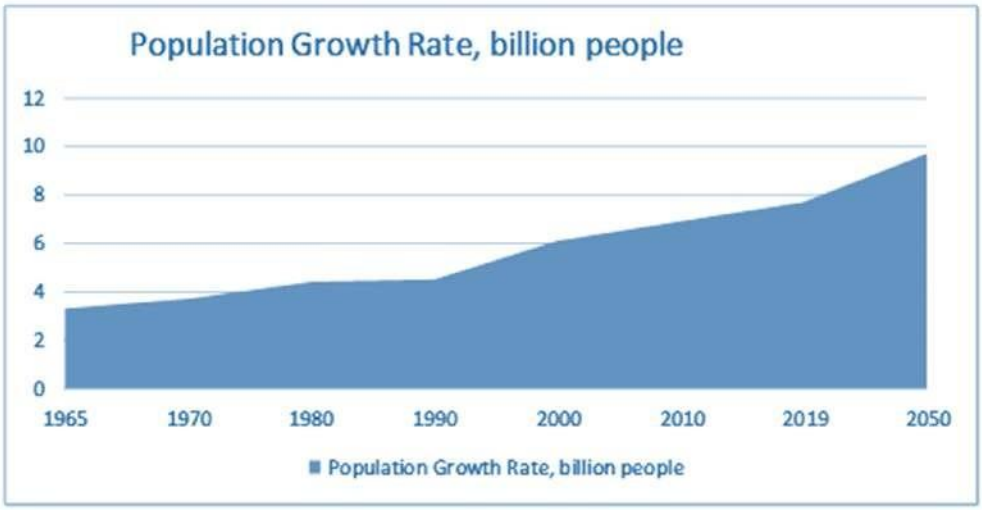

Fig. 1. Population Growth Rate, billion people

ing. According to statistics, by the XXth century the population of the Earth was growing slowly. Its rapid growth in the XXth century is due to the fact that during this period mankind experienced two world wars.

According to forecasts of one of the UNO programs, namely UNDP, the following changes are expected by the middle of the XXI century. First, by 2022, India will become the world leader in terms of population, ahead of China. Second, the popula- tion of Nigeria will increase by about 400 million, which will exceed the population of countries such as Pakistan and Brazil. Third, the United States will become the third most populous country in the world. Fourth, Russia's population will shrink by 10%, and that result will remove the country from the list of the world's ten largest countries by population. Fifth, in 18 countries, mainly in Eastern Europe, the population will also decline; while in North Africa, it will double. For example, the population of Africa will increase by about 2.4% and Europe - by 0.04%. (World Population Prospects: The 2017, 2020).

China	1.38 billion, or 20% of the Earth's population
India	1.28billion, or 17% of the Earth's population
The USA	326 million
Indonesia	260 million
Brazil	207 million
Pakistan	205 million
Nigeria	191 million
Bangladesh	157 million
Russia	142 million
Japan	126 million

Such demographic changes cause a number of challenges. In particular, increasing the burden on the world's ecosystems and as the consequence, there is rapid development of human natural resources (energy, water, food, etc.).

The other aspect of the demographic problem is the global aging, particularly in the Western and Eastern Europe. According to the statistics, in the middle of the XXth century 8% of the Earth's population were 60+ people. Today there are 12 % of such ones, or 900 million people. According to forecasts, by 2025 there will be about 1.2 billion aged people, or 22%. (World Population Prospects: The 2017 Revision).

Thus, the circumstances listed above have the corresponding consequences. In particular - the "shortage" of labor, slowdown in economic development, pension problem, health care system problem and others.

Another equally important issue today is the problem of global migration. On the one hand, it can be considered as overcoming the aging population problem; however, on the other hand, it changes the ethnic, national, religious, cultural picture of the world, creating all sorts of conflicts. For example, the growing number of Latin America migrants to the United States and refugees from Syria to the countries of Western Europe, like France, Germany.

Therefore, a conscious attitude to these demographic data indicates that in the nearest future humanity will face new, extremely important environmental, economic and social problems.

That is why it is necessary to provide the purposeful population policy, when states are the main subjects, which have a significant impact on the population reproduction in the right direction for a particular society. However, it should be taken into consideration that most demographic issues, such as marriage, fertility, divorce, migration, etc., are an individual's personal matter, so demographic processes cannot be managed through different compulsion or prohibition, although such attempts were made and are still being made in humankind's history.

In our opinion, regulation of the demographic processes is possible only through organization of the proper education, in particular, through distribution and implementation of a family planning program, which includes two main levels. The first one is the macro level, which involves the activities of both governmental and non-governmental organizations and includes creating the programs of responsible parenting that provide for upbringing a desirable number of children in the family. The second level is the micro one that involves making individual decisions about the number of children in the family. This right is granted by a number of international agreements and is regarded as one of the fundamental human rights.

The burden on nature is also connected with the world production increase. In the modern world, every second employee's work is related to the environment (work in the field of forestry, fishery, etc.) According to the USA researcher Mattew Hansen and his colleagues, who used remote methods to study the Earth's surface, namely installing a MODIS spectroradiometer onboard US satellites, in 2000 the total area of forests on all the continents was 32.688.000 square kilometers (3.268 million hectares). However, by 2005 it had significantly reduced by 1.011.000 square km (1.011 million hectares). Thus, the average annual forest loss was 0.6% (Hansen Matthew P., 2010). However, it should be noted that forests are unevenly distributed on continents. Therefore, in 64 countries with 2 billion inhabitants there is 0.1 hectare of forests per capita. The five most forest-rich

countries (Russia, Brazil, Canada, USA and China) account for 53% of the total forest area; Russia has 20% of the world's total forest area, while ten countries have no forests at all, and in other 54 countries forests cover less than 10% of their total area.

Besides, the constant growth of the Earth's population leads to excessive consumption of forest resources and decrease in the forest area. The annual volume of timber harvests in the world exceeds the annual growth by 20 - 24%. The wood of high quality is produced only from 20% of the deforestation area, while 80% of the territory is used for producing low-quality wood. (Genyk Ya. V., 2011). Rapid deforestation is taking place, in particular, in South America and Africa, where the area of forests decreased by 4 million and 3.4 million hectares respectively, during 2000–2010.

The most important issue that arises in the process of environmental impact is the sustainability and survival of the biosphere, because it depends on the survival of other living things on the Earth.

Global warming is also one of the main threats nowadays. According to the statistics, the twentieth century was the warmest in the history of the Earth. As a result, there is climate change, average temperature increase, etc.

The American researcher Hilary Greaves points out that the amount of emissions into the atmosphere is directly related to the amount of the Earth's population. That is, interrelation between these problems requires their complex solution. The researcher notes that "climate change is primarily related to the emissions of various greenhouse gases, which are constantly increasing. For example, in 1970, the global amount of anthropogenic emissions was 27 billion tons of CO_2 a year; by 2010, this figure came to 49 billion tons a year and it is expected to rise. The result of these emissions is global warming from 1.5 to 4° C" (Greaves H., 2019).

Examining the probability of climate change risks, American researcher Lara Buchak argues that modern humanity must pursue a prudent climate policy and pay sufficient attention to any consequences from the most threatening to the most optimistic, and therefore direct their activities, always remembering the responsibility to future generations, in what conditions they will live and develop. "We must organize our activities with restraint, appropriately assess all possible risks, from climate catastrophe to relatively small risks so that it does not cost the next generation too much." (Buchak L. 2019).

The researcher focuses on two main aspects in assessing climate change. The first is the organization of planetary climate policy. The second is the individual policy of the country. These two aspects are interrelated and they accordingly form the responsibility of each individual for the future fate and development not only of their region, state, but also the world as a whole. Indeed, today we go beyond the local development and the local responsibility, because we form two types of identity - local and global, which do not contradict each other and are not opposite, this reveals their unity. Therefore, L. Buchak quite rightly notes "the interests of future generations should be just significant and valuable for modern people" (Buchak L. 2019). The formation of this type of responsibility should include all possible ways from philosophy, ethics to environmental education programs, starting with preschool, school education and educational activities of public organizations, associations to involve more people in solving environmental problems of present. Moreover, the development of information and communication technologies provides such opportunities for humanity to conduct various flash mobs, actions, etc. The organization of environmental policy, as noted by L. Buchak, "should be as fine-grained as possible, and should include both restrictions and ways to adapt to possible changes" (Buchak L. 2019). Thus, this indicates that such an environmental policy has two directions. The first is a policy that aims to increase or decrease the probability of drastic climate change. The so-called "precautionary policy", which is able to anticipate an appropriate climate change and offer to reduce carbon emissions. Moreover, the second is the policy of allowing any level of carbon emissions. That is, the most industrialized countries in the world, in particular the United States, Japan do not reduce carbon emissions, but have the opportunity to buy interest from other countries. One of the steps to address these issues was the adoption of the Kyoto Protocol in 1997 under the aegis of the United Nations, which came into force in 2005. The protocol obliges all industrialized countries to review their environmental policies and reduce emissions. It should be noted that in 1997 the United States did not sign this agreement, however, did it only after powerful hurricanes, including Katrina, had passed over the United States.

The Kyoto Protocol was replaced in 2015 by the Paris Climate Agreement, which was supported by 195 countries and ratified by 175 countries under the UNO Convention. The new agreement contains two strategic goals - the first one is regulation of carbon dioxide emissions and, the second is prevention of increase in the global average temperature by more than 2 degrees.

Unlike the Kyoto Protocol, the Paris Climate Agreement stipulates that all the states undertake ob-

ligations to reduce harmful emissions into the atmosphere, regardless of their level of economic development. Every 5 years, the participating countries will report on the contributions made to the implementation of strategic goals and form new goals. The first report of the country should be published in 2023.

Scientists have been actively monitoring the rate of harmful emissions into the atmosphere. These emissions affect the state of the ozone hole over Antarctica. (The Antarctic Ozone Hole Will Recover)

cal elements that deplete the ozone layer. The effect of this agreement shows that by 2075 the size of the hole will return to the level of 1980. NASA research and observation at https://ozonewatch.gsfc.nasa.gov/monthly/SH.html gives the opportunity to see dynamics of the Antarctic ozone concentration from 1979 to 2018 (National Aeronautics and Space Administration. Goddard Space Flight Center).

As the result of these processes, glaciers melt intensively, this can lead to flooding of ocean areas.

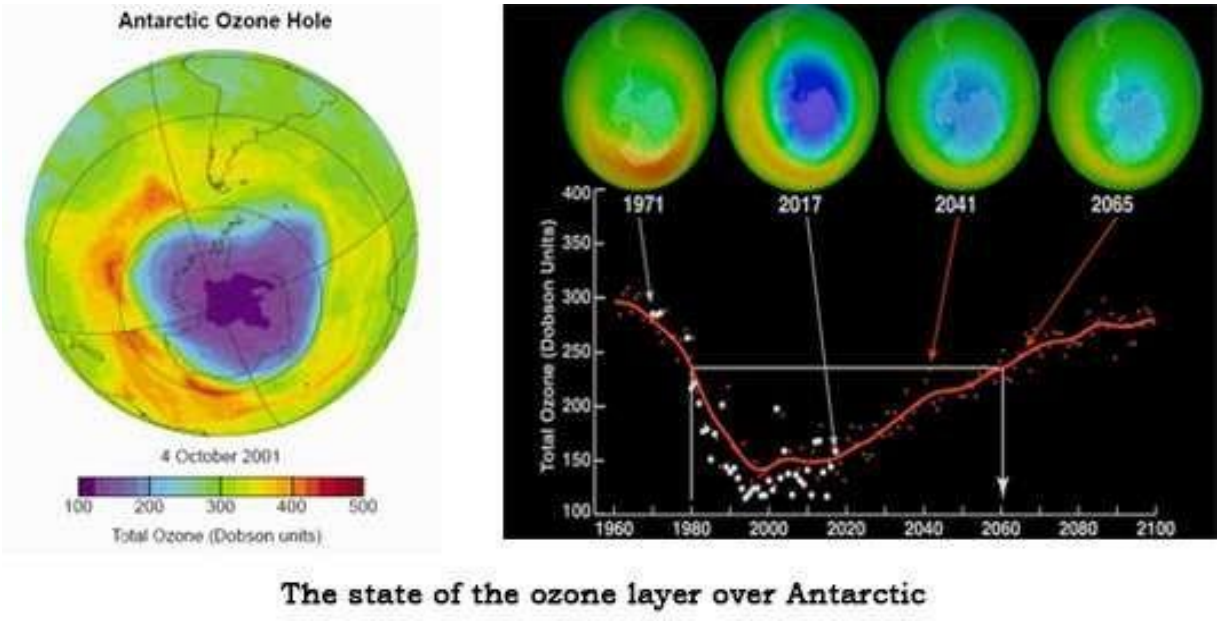

Fig. 2. The state of the ozone layer over Antarctica

The study of the state of the ozone layer around the Earth was intensively begun in the 70 – 80's of the XXth century. At the same time, the Montreal Protocol was signed. It was about protecting the ozone layer by banning chlorofluorocarbons and similar chemi-

The sea level is projected to rise by 17 centimeters, which will change every ecosystem on the Earth. However, a team of scientists has modified one of the most modern computer models of the climate, including the ice melting rate. In addition, it turned

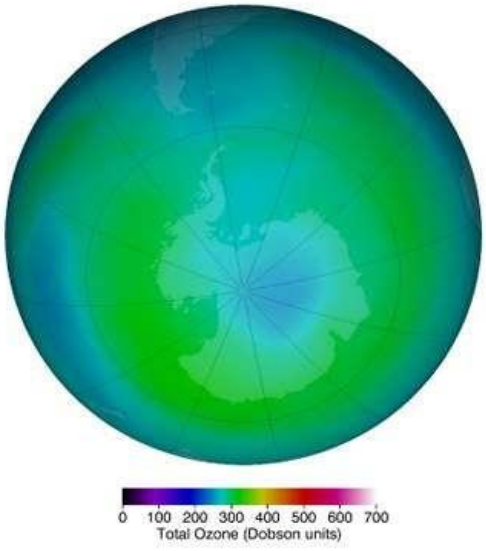

Fig. 3. A snapshot of NASA`s ozone layer. The data is obtained from AMPS on Suomi NPP (March 2020).

out that the fresh water released in this way from the ice sheet slows down the release of heat, as if "preserving" the water around Antarctica. "This is the first and new identified relationship between climate and warming in 20 years. Melting glaciers are delaying global warming – it is still happening, but it will be less intense and will give us a head start in 15 years". (Ben Bronselaer, 2018).

Thus, these studies show that humanity has time to weigh weigh all possible consequences and make constructive decisions.

It is worth mentioning that there are non-governmental organizations, such as the Club of Rome, which is a research association of famous scientists, public figures and politicians, many of whom are Nobel laureates. The research programs of the Club of Rome cover such a range of problems as analysis of strategies for the development of the world civilization; possible options for alternative human development; substantiation of the futility of the arms race; uniting the efforts of all mankind to preserve the environment and achieve social justice on a global scale. Among the representatives of the Club of Rome it is worth mentioning the names of such researchers as A. Peccei, D. Meadows, M. Mesarovich, E. Pestel, E. Laszlo, S. Botkin and many others.

At the present stage of development, humanity has appropriate programs aimed at solving these problems. This should be the program of all humankind, because the solution of these problems depends on the survival of the entire world community. These programs must be implemented in educational processes at all levels and in all countries of the world. For example, the World Wildlife Fund, Greenpeace, the World Commission on Environment and Development; World Health Organization; The World Bank; Friends of the Earth; UN Commission on Sustainable Development; International Maritime Organization; International Atomic Energy Agency; UN Development Program; European Environment Fund; TACIS program, etc., influencing the formation of the global and national policy.

These problems are the consequences of human consumption in the natural environment, mainly in the twentieth century. Intensive development of industry, the final "taming" of the nature, the struggle for possession of natural resources and disregard for the possibility of restoring the biosphere have exacerbated the conflict between humanity and nature. The consequences of this conflict are catastrophic. Not only the survival of humankind, but also life on the planet Earth in general depends on the solution of this conflict. The natural environment has been a field of people's struggle for possession of territory and resources. Thus, the solution to this conflict lies not only in limiting and regulating the impact of technology, but, above all, in the formation of environmental responsibility and a new ethical paradigm of worldview, the realization of the necessary moral values of everyone on the Earth. The current state of the environment requires a new understanding and control of the behavior of both the individual and humanity as a whole. Revision of traditional theories, and the introduction of a new scale of responsibility in the system "nature-human-society", not only by the state in the form of laws and provisions, but, above all, through education, training, active involvement of children in various programs that allow establishing a dialogue "human - nature". According to the first president of the Club of Rome A. Peccei, global problems are inside people's nature, not outside of it. Thus, overcoming these problems including environmental ones is, firstly, the requirement of change in a person himself (Peccei. 1985). Therefore, human activity should be aimed at ensuring the survival of all living things on the Earth in their diversity. Globalization processes, in this case, can bring constructive consequences in resolving this conflict, because humanity is on the path to self-awareness as a global community.

The current stage of development of the world community has created new conditions for the socialization of the individual, a new organization of upbringing and education. The development of the individual, his/her involvement in various social processes at both regional and global levels are now due to high dynamism, and methodological approaches and attitudes to education and training do not have time to establish within these processes. The reason for this is access to and use of various gadgets, which greatly expands the field of communication of an individual.

Indeed, we are both witnesses and participants in various processes of organizing people's lives, which organizes us into an effective civil society that is able to change everything around us. Thus, the emergence of well-known environmental movements is due to their passage from spontaneity, informal gatherings to worldwide recognition, popularity, the available million-dollar support, as well as the real impact on political decisions around the world. Ukraine takes an active part in environmental activities, one of the types of which is environmental movements, the purpose of which is to optimize the development of ecosystems, taking into account both local characteristics and global interests. A huge number of public organizations and movements operate in Ukraine, including the *All-Ukrainian Ecological League*, *Green World*, *EcoRight*, the *Ukrainian Nature Conservation*

Society, *Voice of Nature*, *All-Ukrainian Committee for Support the United Nations Environment Program* (UkrUNEPCom) and many others. They carry out significant work on the implementation of ideas and principles of environmental ethics in modern society and the formation of a new form of environmental consciousness through conferences, congresses, seminars, festivals, environmental actions, etc. The most powerful public organization is the *All-Ukrainian Ecological League*, which includes 22 organizations, which makes a significant contribution to improvement of the environmental situation in the country.

A large number of public initiatives have been already operating in a number of cities in Ukraine, which are independently engaged in the arrangement of parks, park areas, etc. For example, there is the *Group 109* in Lviv. In Odessa, there is a wide range of initiatives, including associations of architects and representatives of various professions who are engaged in the maintaining and optimization of the cultural landscape of the city, creating a system of bike paths, parks and squares. Another group is trying to implement a rather ambitious project, called the *Park of the Future*, which provides a large green area for every resident and guest of the city. The community of Kyiv is also not far behind and presents a large-scale project called *Podolianochka*, which provides for the arrangement of the capital Podil; *Samosad Ecological Park*, modeled after the Princess Gardens in Berlin and New York. In addition, the Square of the Heavenly Hundred is created.

In addition to these organizations and initiatives in Ukraine, there are many non-governmental organizations such as *Lybid Exists*, *Carrot Club*, *Ukraine Without Rubbish*, *Green Incubator*, *Kyiv Cyclists' Association*, *World of Education*, *Rivne Ecoclub*, *zelenka*, *Ekoltava*, *Toloka Association*, *The Animal City*, *Eco-Centre*, etc.

Ecological awareness of Ukrainians is increasing which is confirmed by the fact that since 2015, in particular, such cities as Kyiv, Odessa, Kharkiv and Kherson joined the Global Climate March, taking place annually on November, 29. It means that the society has reached a new level of ecological development. Nowadays, local problems though they are rather important, especially in the industrial regions of our country, are not the only issues that worry Ukrainians. Ukrainian people are also concerned about global problems and get engaged in their solving.

Therefore, the relevant issue for today is self-organization of people who are not indifferent to further development of the "human-nature-society" system. Anyone's activity should be organized in such a unity, because a human is simultaneously in these two systems and his or her actions influence their further development.

Both governmental and non-governmental institutions are important for eco-awareness forming as well as for the education and upbringing processes. The example is the scout organization *Plast* that has its representatives in many world countries, including the USA, the UK, Germany, Ukraine and others. This organization has a clear direction, namely the comprehensive personality development. To implement this idea, they involve such training components as love and respect for nature, self-education, responsibility forming etc. The upbringing program includes the following key elements: competitions (intellectual, creative, sportive) and forming ecological awareness (herewith the scouts get both theoretical knowledge and practical skills as learning process includes arranging camping and excursions. The organization arranges at least one hundred camps a year. Therefore, the current stage of societies' development has many opportunities to upgrade the educational process. Due to that, a person's responsibility for themselves and their actions is formed at the earlier age as well as a person is sooner involved in environmental preservation, its restoration etc.

Therefore, an integral part of the educational process is ecological education, which must be directed to acquiring ecological knowledge and skills, environmental thinking and ecological behavior. "The main goal of eco-education is the formation of ecological awareness as a special form of social responsibility that reflects the interaction of these two systems. By its goals and orientations, eco-awareness is aimed at forming a global strategy for preventing environmental catastrophe at both the local and global levels" (Kampov, Kasynets, Maslygan, Medvid, 2018). This approach to ecological education is considered within the development of ecotourism. In our opinion, it is rather relevant to Ukraine with its ecosystems' diversity, one of which is the Carpathians. The organization of tourism can have several aspects, including education, upbringing, learning traditions of ethnic groups and working with different age groups from preschoolers to the elderly.

The modern world's political, economic and ecological interdependence should be presented in the ecological education as a significant element, that is, the aim of this educational process branch should be the way from regionalism to globalism, as the locally made decisions can have large-scale consequences, such as the Chornobyl disaster. The current stage of the ecological education should develop a sense of global responsibility and solidarity between different

regions and countries to form a constructive dialogue and interaction at international cooperation level which would guarantee preserving and optimizing the level of the environment development.

To organize this model of the ecological education, governmental institutions, such as the Ministry of Education and Science, the Ministry of Youth, Tourism and Sports, the Ministry of Ecology and Natural Resources and national nature parks should interact with non-governmental entities in the form of ecological movements, public organizations and tourist associations, which should be open and ready for all sorts of excursions, introductory lectures and seminars to familiarize their listeners with the peculiarities of their region's ecosystems. They also should create advertising products, posters, network commercials, film and cartoon industry, photo-reproductions, museums as well as arrange mountain paths and develop ecotourism etc. These steps create the wide range of informational activity on ecosystems of different regions not only in a particular country but also in the world as a whole, presenting different objects and their peculiarities etc. For example, Ukraine has had such initiatives for a long time. They are the *Hutsul Alps, the Ukrainian Venice, Chernivtsi Prague, Transcarpathian Japan, the Ukrainian Maldives* and many others. There have been created TV projects like *The World Inside Out, 7 wonders of Ukraine*. Various tourist organizations have their pages on social networks like Couloir, Globe, etc. There are a lot of national parks, for example, the National Nature Park *Synevyr* besides its nature protection function informs people about the natural and cultural values of the protected territories, organizes educational activities, etc.

Modern youth consciously and actively engages in forming their future, demonstrating that humankind has already moved to the new paradigm of development of ecological awareness from the local, regional one to the global one. Young people do not need to develop and implement methodological recommendations on development of ecological consciousness into the educational process. It is "something from the past" for them. They are actively involved in all processes thanks to dissemination and consumption of information around the world and about the world. For example, there is National Ecological and Naturalistic Centre of School Students in Ukraine, which holds conferences and international competitions, issues newspapers and magazines and implement different projects (https://nenc.gov.ua).

Thus, in March 2019, climate protection actions took place in almost 100 countries of the world. About 1300 demonstrations were held. In particular, there are constant actions of the "Fridays for Future" movement in London and Hamburg. The young generation does not wait for reaching the appropriate age to influence environmental policy-making. They actively work and support such slogans as "Planet B does not exist", "March now – Flood then", "You can overcome the school skips but not the climate change", etc. For example, world-known Swedish student Greta Thunberg aged 16 is an activist against climate change. For several months, she has been picketing on climate protection instead of school on Fridays. That is why one of the American editions has included the student in the list of the most influential teens of 2018.

The participants of the ecological movement publicize their actions on social networks, such as Facebook, Instagram and Twitter, as well as on various Internet platforms. The movement has its own channel on Youtube.

Thus, modern information and communication technologies provide many opportunities for self-organization of various environmental and climatic movements. First, holding many flash mobs, challenges, actions – from the coordination of the venue, to fundraising and more. That is, the current stage of formation of ecological consciousness, education is characterized by the fact that starting from individual actions it grows into global ecological, climatic movements. For example, there are about 155 groups only in Germany. Mass culture is also used with its powerful propaganda functions, namely film-industry (for example, such films as *Tsunami*, *Human Child*, *The Day after Tomorrow*, *The Postman* and others) and musical industry (the national group *Antibodies* filmed some video-clips for the songs *Catch the Moment* and *Hello* which reflect "human-nature" relationship that has global dimension of existence instead of local one).

Conclusions. The development of modern humanity takes place in the continuum of two extremes' existence. On the one hand, large-scale global threats, namely climate change, demographic problems, harmful emissions into the atmosphere (including carbon), which are associated with increasing production rates. On the other hand, there are new ways and means to solve these problems, primarily due to humankind's awareness of being a single entity, global community that is equally responsible for everything happening in their common home named the Earth. The new ways include involving more and more conscious people through different organizations, actions and movements. Only together humankind can solve the problems it faces.

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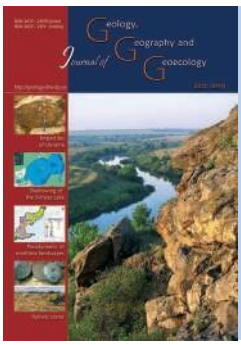

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Audit in ensuring the effectiveness of tourism management

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Abstract. Due to the spread of the coronavirus pandemic, the losses of the tourism industry in Ukraine in 2020 are estimated at more than 1.5 billion dollars. USA. The current situation requires an adequate response from the government and business, which leads to an increased need for the use of scientific tools to justify the options for optimal economic development and relevant management decisions. Under such conditions, the key to sustainable development of the tourism industry should be the maximum use of management tools: management accounting, analysis and audit, implemented in the concept of their effective interaction. The aim of the article is to improve the theoretical and praxeological principles of management accounting, analysis and audit in the tourism management system, by developing the concept of their synergy and substantiation of prospects for implementation as a key imperative for sustainable development of the tourism industry. The economic and social significance of tourism in modern conditions is determined by the fact that the tourism business contributes to economic development, developing related industries, promotes employment, growth of gross domestic product, is a significant source of foreign exchange earnings. Experts from the World Tourism Organization emphasize the historical sustainability of tourism and its ability to create jobs after crises, and emphasize the importance of international cooperation and ensuring that the sector becomes a central part of the recovery effort after the coronavirus pandemic. To increase the efficiency of the tourism industry, as an imperative for sustainable development of the national economy, it is advisable to use such management system tools as management accounting, analysis and audit, implemented in the concept of effective interaction. The article identifies the place of a separate concept in the formation of the paradigm of management accounting, analysis and audit. One of the concepts that contributes to the modern audit paradigm is the concept of synergy between internal and external audit proposed in this study. A qualitative feature of the proposed concept is the two-vector direction of its action, as it is aimed at meeting the needs of internal and external users of information, which fundamentally distinguishes it from other concepts of audit. The proposed scheme of management of the tourist enterprise on the basis of interaction of administrative accounting, business analysis and audit will promote their practical realization in activity of the subject of tourist business. One of the concepts that contributes to the modern audit paradigm was the concept of synergy of internal and external audit proposed in this study. A qualitative feature of the proposed concept is the two-vector direction of its action, as it is aimed at meeting the needs of internal and external users of information, which fundamentally distinguishes it from other concepts of audit. The practical implementation of the interaction of management accounting tools, business analysis and audit at the micro level will also be facilitated by the developed scheme of tourism enterprise management based on the interaction of management accounting, business analysis and audit.

Key words: tourism, tourism management, coronavirus pandemic, accounting, analysis, audit, audit synergy

Аудит в забезпеченні ефективності туристичного менеджменту

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Анотація. Внаслідок поширення пандемії короновірусу втрати туристичної галузі в Україні в 2020 році оцінюються у понад 1,5 млрд дол. США. Ситуація, що склалася, потребує адекватного реагування з боку уряду та бізнесу, що обумовлює підвищену потребу у застосуванні наукового інструментарію обґрунтування варіантів оптимального розвитку економіки та прийняття релевантних управлінських рішень. За таких умов, запорукою сталого розвитку туристичної галузі має бути максимальне застосування інструментів менеджменту: управлінського обліку, аналізу та аудиту, реалізованих в концепції їх ефективної взаємодії. Метою статті є вдосконалення теоретичних та праксеологічних засад управлінського обліку, аналізу та

аудиту в системі туристичного менеджменту, шляхом розробки концепції їх синергії та обґрунтування перспектив реалізації як ключового імперативу забезпечення сталого розвитку туристичної галузі. Економічна та соціальна значущість туризму в сучасних умовах визначається тим, що туристичний бізнес сприяє розвитку економіки, розвиваючи суміжні галузі, сприяє зайнятості населення, зростанню валового внутрішнього продукту країни, є вагомим джерелом валютних надходжень. Експерти Всесвітньої туристичної організації підкреслюють історичну стійкість туризму та його здатність створювати робочі місця після кризових ситуацій, а також наголошують на важливості міжнародного співробітництва та забезпечення того, щоб цей сектор став центральною частиною зусиль з відновлення після пандемії коронавірусу. Для підвищення ефективності функціонування туристичної галузі, як імперативу сталого розвитку національної економіки доцільно використовувати такі інструменти системи менеджменту, як управлінський облік, аналіз та аудит, реалізованих в концепції ефективної взаємодії. В статті визначено місце окремої концепції у формуванні парадигми управлінського обліку, аналізу та аудиту. Однією з концепцій, яка здійснює свій внесок у сучасну парадигму аудиту, можна визначити концепцію синергії внутрішнього та зовнішнього аудиту, що пропонується в межах цього дослідження. Якісною особливістю запропонованої концепції є двовекторність напряму її дії, оскільки вона спрямована на задоволення потреб внутрішніх і зовнішніх користувачів інформації, що принципово відрізняє її від інших концепцій аудиту. Запропонована схема управління туристичним підприємством на основі взаємодії управлінського обліку, бізнес-аналізу та аудиту сприятиме їх практичній реалізації у діяльності суб'єкта туристичного бізнесу. Однією з концепцій, яка здійснює свій внесок у сучасну парадигму аудиту, було визначено концепцію синергії внутрішнього та зовнішнього аудиту, що пропонується у даному дослідженні. Якісною особливістю запропонованої концепції є двовекторність напряму її дії, оскільки вона спрямована на задоволення потреб внутрішніх і зовнішніх користувачів інформації, що принципово відрізняє її від інших концепцій аудиту. Практичній реалізації взаємодії інструментів управлінського обліку, бізнес-аналізу та аудиту на мікрорівні також сприятиме розроблена схема управління туристичним підприємством на основі взаємодії управлінського обліку, бізнес-аналізу та аудиту.

Ключові слова: туризм, туристичний менеджмент, пандемія короновірусу, управлінський облік, аналіз, аудит,аудиторська синергія

Introduction. Dynamic economic conditions, turbulence of the economic environment, complexity of mobilization and distribution of resources, deepened by the pandemic of the coronavirus, have caused new challenges and a serious threat to both the world and domestic economy. According to the most optimistic forecast of the International Monetary Fund, the spread of the coronavirus will cause the world economy to fall by at least 0.01%. Forced preventive measures, which are designed to prevent the spread of the epidemic in Ukraine through the introduction of quarantine, will at the same time cause a significant blow to businesses, especially small ones. The expected consequence of the suspension of business activity will be a reduction in GDP, a decrease in tax revenues to the budget, a reduction in foreign exchange reserves, a devaluation of the national currency and an increase in the risk of default. The sphere of services, in particular, tourism are under threat.

The tourism industry has suffered the most from the spread of the coronavirus pandemic. According to the analytical note of the National Institute for Strategic Studies "On the development of tourism in Ukraine in conditions of increased epidemic risks", the losses of the tourism industry in Ukraine in 2020 are estimated at more than 1.5 billion dollars USA (Zhalilo, Kovalivska, Filipenko, Khiminets, Golovka 2020).

The current situation requires an adequate response from the government and business, which necessitates the increased need to use scientific tools in order to justify options for optimal economic development and to make relevant management decisions. In such circumstances, the key to sustainable development of the national economy and rational management should be the maximum use of management accounting, analysis and audit tools implemented in the concept of their effective interaction.

The aim of the study is to improve the theoretical and praxeological foundations of management accounting, analysis and audit in modern economic conditions by developing the concept of their synergy and substantiating the prospects for implementation as a key imperative to ensure the sustainable development of the national economy.

Literature review. The theory, methodology, practice of management accounting, analysis and audit is the subject of scientific interest of scientists as Bondar, Iershova (2019), Grosu, Anisie, Hrubliak, Ratsa (2019), Komirna, Miniailo, Nezhyva (2019).

Scientists such as Grosu, Anisie, Grublyak, Rats (2019) in their researches reveal the issues of management accounting as an important component of the enterprise accounting system. Achieving the goals of minimizing production costs, rationalizing the use of available resources and maintaining product quality, according to the authors of the article, is possible through the use of management accounting tools «Kaizen», «5Whys», «Six Sigma» and more. The result of the authors' scientific work are concepts and methods of evaluation and reporting aimed at supporting management decisions. The problematic issues of management accounting theory and practice in the context of risk management are revealed in

their works by Bondar and Ershova (2019). It resulted into scientists forming their classification for strategic management accounting purposes. Suggestions for structuring the strategic risk management process should also be included in the scientific work of these authors.

Theoretical and praxeological foundations of business analysis and audit in the process of providing management support systems at micro and macro levels have also gained wide coverage in the scientific literature, in particular, in the scientific works of Andryeyeva, Hotsuliak, Gorbachenko (2018), Komirna, Miniailo, Nezhyva (2019), as well as other scientists of the Department of Financial Analysis and Audit of Kyiv National University of Trade and Economics (2020). Significant developments in the improvement of audit working papers are presented in the research by Bondar (2018). The result of the work of such researchers as Andreeva, Gotsulyak, Gorbachenko (2018) are the disclosure of the features of the use of analysis tools in assessing the current state, institutional risks and prospects for the development of the Ukrainian marine industry. The field of tourism has been studied by scientists in various aspects. Sagalakova (2016) in monograph researched theoretical and practical aspects of price formation for a tourist product, formed a network of business processes of a tourist enterprise. New promising areas of tourism development and features of innovative types of tourism are considered by Popova et al. (2020) and Scheyvens, Biddulph (2018). McKercher, Mak (2019) in his research conducts a comprehensive analysis and assessment of current trends in international tourism, identifying promising areas for its activation and further development.

Recognizing the importance of the research above, it should be noted that the study of the features of the use of management accounting, analysis and audit to inform decision support at any level of economic management is not losing its relevance (Yankovyi et al., 2020). The rapid development of globalization, digitalization of the vast majority of human activities, the coronavirus pandemic in 2020 and other macroeconomic factors have significantly affected the state and directions of tourism, which requires research by scientists and practitioners, finding new ways to improve tourism management. The implementation of the functions of macroeconomic planning, strategic forecasting, transparency and reliability of financial information of economic entities, ensuring the effectiveness of management decisions at the level of the national economy should be based on scientifically grounded results of management accounting, analysis and audit. Maximizing the beneficial effect of using accounting, analysis and audit tools to ensure the sustainable growth of the national economy is possible by developing and implementing the concept of their synergy.

Materials and methods of research. In the context of numerous crises and economic, environmental and social problems, society has needed to find a new way of development that would allow economic systems to function effectively and in a balanced way in combination with environmental and social factors. One of the theories that has become an alternative to the concept of economic growth, which is dominated by economic interests, is the concept of sustainable development. The strategy of sustainable development is one of the key and priority in all sectors of the national economy. Its principles and main provisions are aimed at achieving harmony between the growth of economic indicators, stability in the social sphere and environmental protection. Preservation of natural resources, maintaining their sustainability and transition to resource-saving, energy-efficient technologies is almost one of the key tasks on the agenda. The system of a holistic paradigm of sustainable development of society is the concept of sustainable development of tourism, which is based on at the present stage, laid at least an understanding of the balanced unity of economic, social and environmental characteristics. Given the urgency of this issue, the United Nations General Assembly has approved the adoption of 2017 as the International year for sustainable tourism.

Sustainable tourism development is a long-term development of tourism, which achieves a balance in the implementation of economic, environmental, socio-cultural development goals based on the rational use of tourism resources and comprehensive partnership, taking into account the interests of all stakeholders.

For a meaningful understanding of sustainable development are crucial three elements that shape it as another type of development: in the formation of tourism policy invariably take into account the sustainability of development processes; sustainable development inevitably implies adherence to the idea of social justice and means not only quantitative growth, but also qualitative improvement of meeting needs; one of the basic principles is the harmony of human development, as well as innovative development. In addition, sustainable development must ensure the interaction of the economy, society (society) and the natural environment. Thus, the main components of the concept of sustainable tourism

development in the region are: environmental, economic and socio-cultural stability (Bantash, Koval, Bashynska, Kozlovtseva, 2020).

The economic and social significance of tourism in modern conditions is determined by the fact that the tourism business contributes to economic development by developing such industries as agriculture, trade, construction, communications, production of consumer goods; contributes to employment, growth of potential and real gross domestic product of the country, is a significant source of foreign exchange earnings and a means of ensuring a positive balance of payments of the country.

The tourism industry has developed quite dynamically in recent decades in Ukraine (Table 1).

The data in Table 1 show a significant increase in the number of tourists served by the tourism industry, especially in 2018-2019 (in 2019, the growth rate exceeded 200% compared to 2017). Over the last 20 years, the ratio of tourists traveling abroad and domestic tourists has changed significantly. In 2000, the number of domestic tourists was almost 5 times higher than the number of outbound, in 2019 the trend is the opposite – the number of tourists traveling abroad is more than 10 times higher than the number of domestic tourists.

The COVID-19 pandemic in 2020 made significant changes in the performance of the tourism industry. The late start of the holiday and recreation season due to the introduction of restrictive measures also created a cumulative effect, which negatively affected the leisure and travel industry, as well as related industries – hotel and restaurant business, transport (passenger traffic), retail, entertainment and institutions culture. Restrictions on movement imposed by states to prevent the spread of COVID-19, falling incomes due to the economic crisis and recession potentially increase the demand for leisure within Ukraine. Domestic tourism is the main driver of preservation and revival of the industry. It is worth noting that the leading tourist countries of the Black Sea region (Romania, Bulgaria, Turkey) also focus in 2020 on the development of domestic tourism, and not only encourage citizens to relax in domestic resorts, but also introduce incentives. The possibility of attracting tourists from neighboring

Table 1. Number of tourists served by tour operators and travel agents in Ukraine (persons)

Year	Number of tourists served by tour operators and travel agents, total	Including		
		incoming (foreign) tourists	outbound tourists	domestic tourists
2000	2013998	377871	285353	1350774
2001	2175090	416186	271281	1487623
2002	2265317	417729	302632	1544956
2003	2856983	590641	344332	1922010
2004	1890370	436311	441798	1012261
2005	1825649	326389	566942	932318
2006	2206498	299125	868228	1039145
2007	2863820	372455	336049	2155316
2008	3041655	372752	1282023	1386880
2009	2290097	282287	913640	1094170
2010	2280757	335835	1295623	649299
2011	2199977	234271	1250068	715638
2012	3000696	270064	1956662	773970
2013	3454316	232311	2519390	702615
2014[1]	2425089	17070	2085273	322746
2015[1]	2019576	15159	1647390	357027
2016[1]	2549606	35071	2060974	453561
2017[1]	2806426	39605	2289854	476967
2018[1]	4557447	75945	4024703	456799
2019[1]	6132097	86840	5524866	520391

[1] Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and the temporarily occupied territories in Donetsk and Luhansk oblasts.

2000-2010 – according to the Ministry of Infrastructure of Ukraine, starting from 2011 – according to the State Statistics Service.

Sourse: State Statistics Service of Ukraine (2019)

countries, in particular the Republic of Moldova and Belarus, should also be taken into account, for whom visiting Ukraine has certain advantages: logistical accessibility (especially for Moldovan citizens), no language barrier, developed routes, etc. However, the practical implementation of this demand will depend on the ability to establish the activities of the resort infrastructure in the face of anti-epidemic restrictions (State Statistics Service of Ukraine, 2019).

For many countries of the world, the priority area of the economy is defined as international tourism, as it provides the lion's share of the total national income of states and becomes a direction of international specialization. Revenues from tourism accounted for about a tenth of global economic growth. In recent years, the industry has even been called its global driver, because it has developed much faster than the world economy as a whole (Kvach, Koval, Hrymaliuk, 2018). Ukraine with its favorable geographical position, available tourist and recreational potential, historical and cultural heritage has also been actively integrated into the global tourism industry, positioning itself as an important tourist destination (Brandão, Costa, Buhalis, 2018). Tourist activity at the present stage has been interrupted due to the spread of coronavirus around the world, the emergence of a new strain of which 2019-nCoV was confirmed in December 2019 in Wuhan (China). Given the uncertainty caused by the COVID-19 pandemic, the issue of prospects for further development of international tourism becomes particularly relevant.

Experts from the World Tourism Organization emphasize the historical resilience of tourism and its ability to create jobs after crises (Kostetska et al, 2020), and emphasize the importance of international cooperation and ensuring that the sector becomes a central part of the coronavirus recovery pandemic.

Ukrainians finally have the opportunity to reorient to the domestic tourism market: 2020 was declared the year of rural tourism by the National Tourism Organization of Ukraine. Certain prerequisites for the successful development of rural tourism in Ukraine are a relatively low level of urbanization, favorable natural conditions, low employment of the rural population, as well as preserved traditional rural culture and ethnic identity.

The current situation requires an adequate response from the government and business, which leads to an increased need for the use of scientific tools to justify the options for optimal economic development and relevant management decisions.

According to official data of the State Statistics Service of Ukraine (2020), the nominal GDP of Ukraine for 2015-2019 increased from 1979458 to 974564 million UAH (by 100.8%). For comparison, real GDP in the same analyzed period increased from UAH 1430290 to UAH 3675728 million (by 157%). This data indicates a rather good dynamic, which is unlikely to persist in the current 2020 year due to the suspension of business entities. The current situation in the Ukrainian economy, despite the persistence of a number of significant problems and risks, indicates the gradual formation of a qualitative basis for further stable economic development in the new economic realities. Growth will be supported by domestic demand, namely consumer and investment (Ministry of Economic Development and Trade of Ukraine, 2018).

However, another problem remains. According to preliminary estimates by the Ministry of Economic Development, the level of shadow economy in 2018 amounted to 30% of official GDP and is the lowest since 2009. Given that the shadowing of the economy is considered by experts to be one of the benchmarks for the effectiveness of the reforms being implemented and their acceptance by society, this result is noteworthy. One of the major threats posed by the shadow economy to the economic system is the distortion of the mechanisms of action of laws and instruments of the market, which leads to ineffective mechanisms of stimulating the economy, holding back the economic development of the country. Therefore, the government's efforts should focus, first and foremost, on the implementation of measures aimed at minimizing the impact of systemic factors of shadow economy that remain relevant, namely: low efficiency of the state in providing the institutional foundations for the development of a competitive economy; high level of corruption; poor efficiency of the judicial system; insufficient protection of movable and immovable property rights, including rights to financial assets (Ministry of Economic Development, Trade and Agriculture of Ukraine, 2019).

Results and their analysis. To assess the effectiveness of the tourism industry as an imperative for sustainable development of the national economy should use such tools of the management system as management accounting, analysis and audit, implemented in the concept of effective interaction (Gaddis, 2018).

The concept in science is considered as a general idea of research, which must be provided with a certain justification for the feasibility, necessity, opportunities of realization, disclosure of the way to achieve it. The term «conceptio» means «understanding, system» and can be defined as (Azrilijan, 2004; Pavlyshenko, Topishko, Ivan, 2002):

- a way of understanding, interpreting a particular subject, phenomenon, process, main point of view, a guiding idea for their illumination. The notion of concept is also used to denote the basic, sole design, constructive principle in scientific, artistic, technical, political and other spheres of activity;
- system of views, this or that understanding of phenomena, processes;
- a single, defining concept;
- set of views, way of understanding, interpretation of a particular subject of research, phenomena and processes, a leading idea of their systematic theoretical and methodological characteristics;
- a leading idea that defines the strategy of action in the implementation of reforms, programs and plans.

If the scientific paradigm in general and the paradigm of audit, in particular, involves the introduction of certain scientific achievements by all scientists in a particular field of knowledge, then the concept of audit, like many other scientific fields, provides a defining concept, main idea, a hypothesis of a specific direction, etc. The quantity and quality of concepts in management accounting, analysis and audit enrich it and contribute to the paradigm of management accounting, analysis and auditing (Audit Chamber of Ukraine, 2007). The well-known concepts are (Gaddis, 2018; Katrych, Komirna, 2018; Nazarova et al., 2019):

- audit development;
- materiality;
- independent audit;
- internal audit;
- social-economic concept of audit;
- assurance tasks;
- R. Adams (using a system-oriented method of auditor opinion formation; concept of division of audit activity into audit and related services);
- L. Dixie;
- R. Montgomery;
- structuring the national audit system in Ukraine;
- development of procedural assurance of the audit;
- system-oriented audit (corporate systems);
- quality of professional independent audit;
- оцінки assessing the status of internal audit in the external process;
- models of audit regulation in Ukraine and so on.

Within the framework of the study, the concept is fundamentally different from the theory not only by its incompleteness, the possibility of subjective authorial decision, but also by the fact that it is often characterized by insufficient verification. This feature can be considered as a boundary, a boundary between theory and concept in science (Fig. 1). In other words, the concept can be conditionally defined as a certain «surrogate» form of theory.

The main purpose of the concept is to integrate a certain array of knowledge, the desire to use it to explain, the search for patterns. The concept, being tested by facts, is refined both in content and in terms of its cognitive boundaries. It is fundamentally important that the concept, after all, may not stand the test of practice and be neglected. For the most part, this occurs at the stages of the development of science, when the need for explanation of objects causes the emergence of many conceptual approaches that integrate knowledge and provide more or less correct explanations (Mazaraki, Drozdova, Bay, 2020).

Thus, the concept of the research implies a certain system of initial theoretical propositions, which are the basis of the research search. In the course of a scientific search, the adopted baselines are reviewed, developed, adjusted, if necessary, rejected, modified or upgraded.

Depicted in Fig.1 scheme presents the place of a separate concept in the formation of the paradigm of management accounting, analysis and audit (Gaddis, 2018). One of the concepts «N», that contributes to the modern audit paradigm is to identify the synergy concept of internal and external audit that is offered within this study. A qualitative feature of the proposed concept is the two-vector direction of its action, since it is aimed at meeting the needs of internal and external users of information, which fundamentally distinguishes it from other audit concepts (Fig. 2).

The modern economy as a whole and the economic efficiency of the entity, in particular, require an improvement in the quality of the audit, since quality audit is a factor in economic growth. Considerable aspirations of domestic business entities to participate in international capital markets, labor, financial markets, as well as in other forms of macroeconomic activity, increase of business activity of domestic business entities in these markets, announcement of their strategic plans for preparation

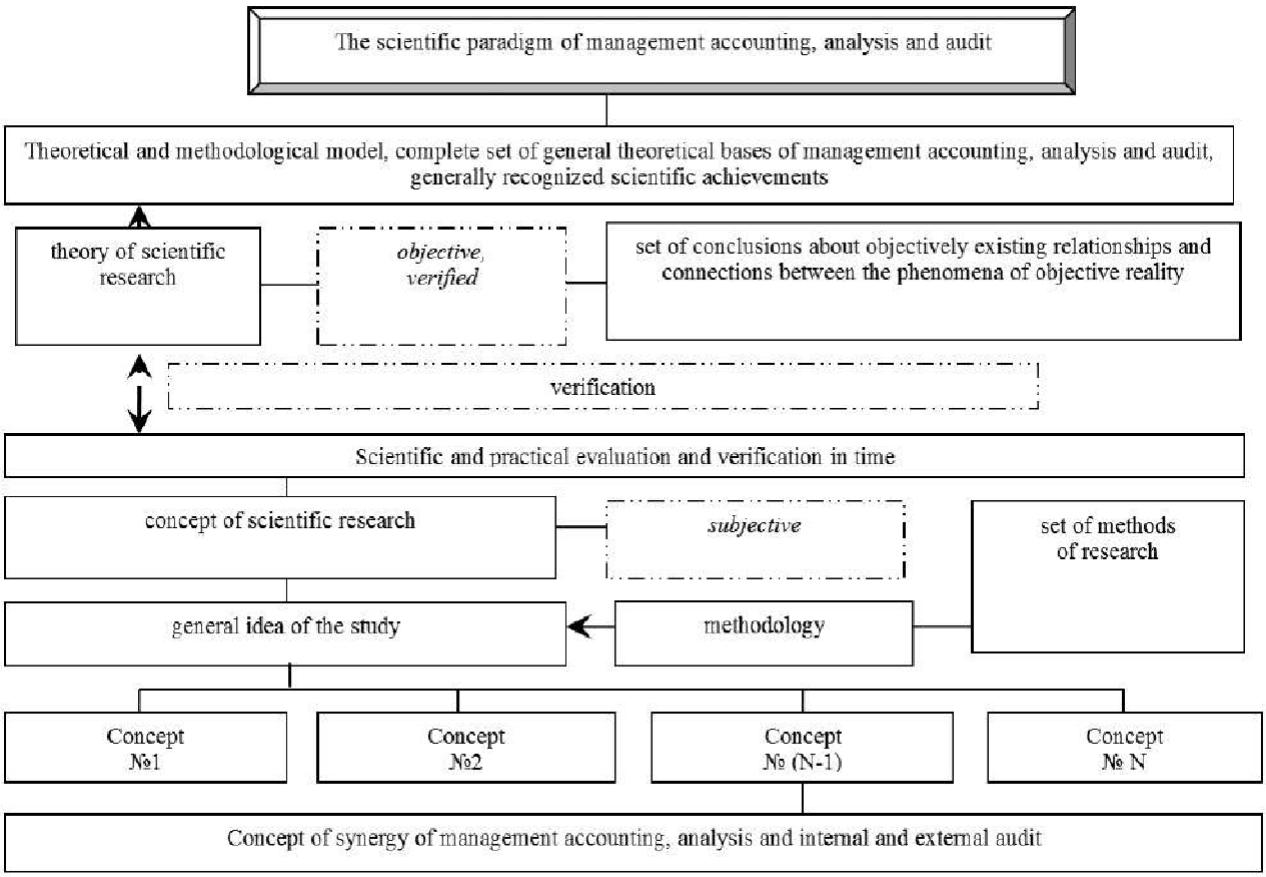

Fig. 1. The place of concept of synergy of management accounting, analysis and internal and external audit in the scientific audit paradigm
Source: developed by the authors

and implementation of IPO, formed requests for targeted investment, encourage owners and CEOs to look for a reliable source of the most accurate and verified information that can be provided by an audit, but because of improperness of its quality does not provide. External audit, both compulsory and proactive, is ordered in Ukraine by a small proportion of economic entities – legal entities.

One of the key problems of the tourism sector in Ukraine is that the vast majority of travel intermediaries are registered in the form of individual entrepreneurs. According to the Law of Ukraine "On Audit of Financial Statements and Auditing", they are not subject to mandatory audit. The vast majority of such businesses do not commission an initiative audit. The consequence is that periodically, in the context of conflicts that arise between the parties, users of tourist services turn to state regulatory authorities.

The active practice of addressing entities to audit firms raises a number of unsolved issues that significantly undermine the confidence of audit clients in its results, among which the quality of the audit, poor user confidence in the audit results, are separately identified. Despite the progress of internal audit and the achievement of external audit, their capabilities are limited, which requires finding innovative approaches to enable them to interact effectively. The concept of audit synergy is aimed at solving some of these problems and, most importantly, improving the quality of the audit.

The efficiency of tourism enterprise management, as well as its economic efficiency and investment attractiveness increase if they are based on the results (or use the results) of synergy of internal and external audit (Ježovita, Tušek, Žager, 2018; Nazarova, Zaremba, Kopotiienko, Mysiuk, 2018). It has become a kind of logical answer, an innovative approach to solving certain problems and shortcomings of internal and external audit.

The development of theoretical and methodological foundations for the synergy of internal and external audit has become possible in the conditions of formation of a new stage of development of the audit – social responsibility in accordance with the socially relevant model of the functioning of the audit, the main determinant of which is the dialectical unity of the requests of the public and the auditor presented. This is achieved by implementing a set of systematic, functional, deterministic, pragmatic, semantic, sensory approaches to the relationship of all

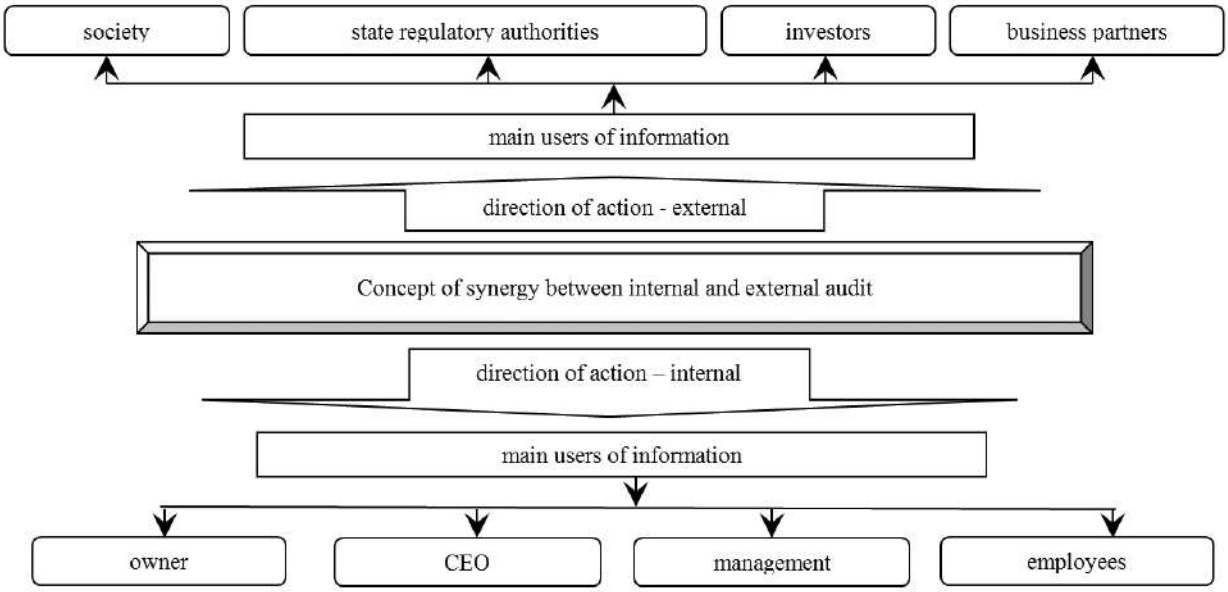

Fig. 2. Two-vector orientation of internal and external audit synergy
Source: developed by the authors

parties involved in the audit activity, public requests for audit results, opportunities and aspirations of economic entities (first of all, public interest entities, further PIE) to provide the information on quantity and quality. The implementation of these theoretical and methodological principles of audit synergy will increase the level of validity of information support of management decisions and obtain additional, synergetic effect, which, in turn, will lead to an increase in the investment attractiveness of economic entities, the individual industry and the national economy due to a possibility to provide state guarantees in part of the validation of the system of national accounts with objective and reliable information.

The concept of internal and external audit synergy is based on the effective interaction between internal and external audit. It aims at obtaining additional confidence in the validity of the auditor's opinion and the management decision taken with it, and is based on the matrix of justification of the need for audit synergy with regard to the importance of the entity for the society, and manifests itself in achieving a balance of interests of the owners and audit entities, and is the result of minimizing audit risks and enhancing the benefits of each type of audit separately.

Maximizing the beneficial effect of the interaction of management accounting, business analysis and audit tools at the micro level is possible by presenting them as elements of the management subsystem of the entity, which permanently affects the managed subsystem – economic activity (Fig. 3).

Thus, the result of implementation of the concept is an increase in confidence: the auditor – in his opinion; individual users of information (both professional and non-professional) – in the accuracy of the information received (investors – in the validity of the choice of investment object); society – that the auditor gave an objective assessment of the financial and economic activities of the entity and its financial statements.

The proposed entity management scheme based on the interaction of management accounting, business analysis and audit will facilitate their practical implementation in the activities of the tourism business entity (Koval et al., 2019; Dwyer, L., Forsyth, P., & Dwyer, W., 2020). Management accounting, analysis and audit tools allow us to evaluate the effectiveness of business as an imperative for the sustainable development of the national economy.

Conclusions. The current downturn in Ukraine requires a timely and adequate response through the development of a science-based system. An important requisition for assessing economic performance as an imperative for the sustainable development of the national economy is the use of management accounting, analysis and audit tools. In view of the foregoing, the results of this study presented the place of a separate concept in the formation of the paradigm of management accounting, analysis and audit. One of the concepts contributing to the modern audit paradigm was the concept of internal and external audit synergies offered in this study. A qualitative feature of the proposed concept is the two-vector direction of its action, since it is aimed at meeting the needs of internal and external users of information, which fundamentally differentiates it from other audit concepts. The practical implementation of the interaction of management accounting, business

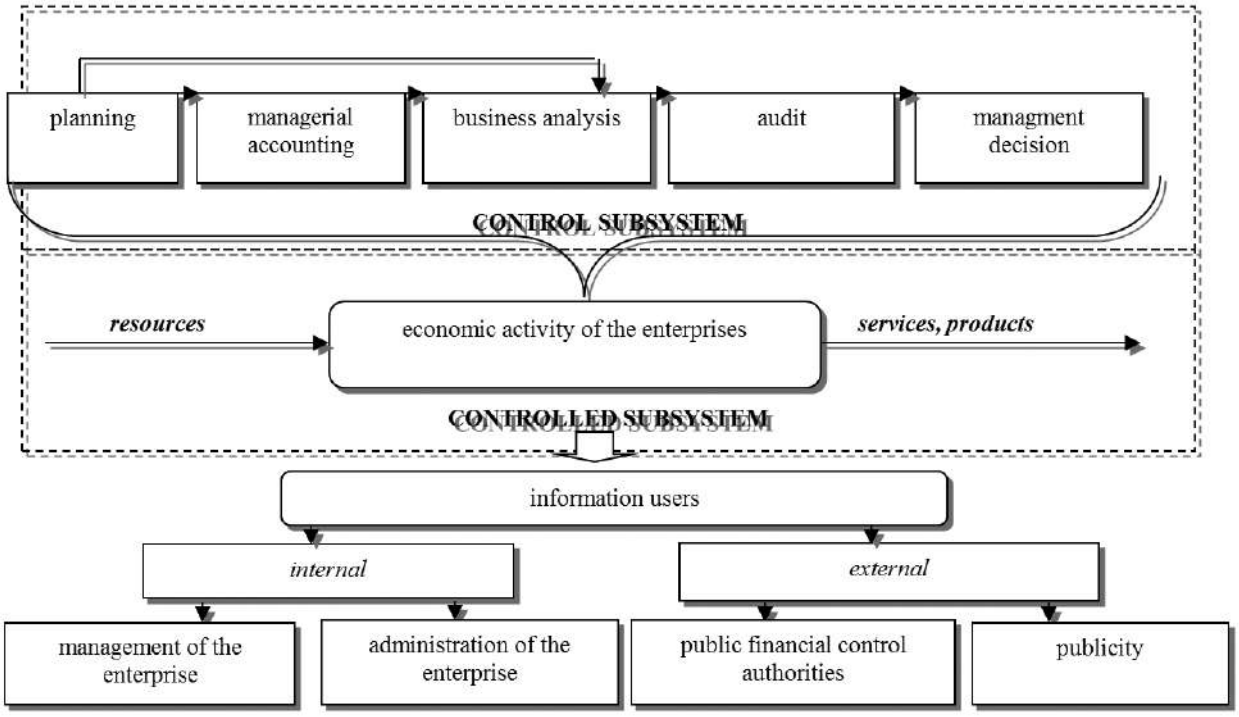

Fig. 3. Management scheme of the entity based on the interaction of management accounting, business analysis and audit
Source: developed by the authors

analysis and audit tools at the micro level will also be facilitated by a developed entity management scheme based on the interaction of management accounting, business analysis and audit, which are presented as elements of the management subsystem of the entity that affects the managed subsystem – economic activity. Investors, potential business partners, users of travel services will have much more confidence in travel companies that have passed an external audit and have a positive audit report. Internal audit, which allows to identify problematic aspects of activity, assess the effectiveness of key business processes and identify areas for improvement, is conducted in less than 5% of tourism enterprises. To increase the efficiency of tourism management of the business entity in the field of tourism, it is necessary to combine the results of internal and external audit.

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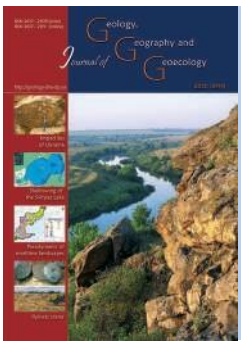

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The new approach to creating progressive and low-waste mining technology for thin coal seams

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Abstract. The problem of mining low-thickness coal seams in the Western Donbas is described in the article. Technological, economic and environmental reasons reducing the effectiveness of traditional technologies for their development are analyzed in detail and the new progressive approach is proposed to solve it. Attention is paid to the importance of hard coal for Ukraine energy independence and thin coal seams, which is the lowest indicator among coal deposits exploited in the developed countries worldwide. The key role of the Western Donbas mines in the Ukraine coal mining industry development is shown, where coal seams with a geological thickness in a range of 0.55 – 0.80 m take more than 50% of coal reserves. It leads to coal clogging and rising of the further enrichment costs. The interrelation of mining, geological seam thickness, and wall rock undercut is established, as well as decade-long tendency out of seam size increase is evaluated. It appropriately correlates with the general tendency of a geological thickness decrease and it leads to an increase of total ash content. The sources are defined and the volumes of waste rock run from coal mine to the surface are quantified, where 80 – 90% are underground mine working development and wall rock undercut while longwall mining operations. The negative influence of the applied mining technologies for low-thickness seams is shown. Whereby existing waste rock dumps are additionally replenished annually by 3.0 – 3.5 million of large-sized coal enrichment wastes and transported back onto waste rock dumps for very high expenses. It is determined that three waste dumps are located near urban settlements, which increases the environmental fee for their placement in three times. The new approach for selective mining of low-thickness seams with rock undercut placement in the gob area is proposed and it is characterized by the addition to the mechanized support of horizontally-closed scraper backfilling conveyor with a tamping device for rock compaction, which reduces the mine rock output by 25 – 30%. The preliminary calculations of parameters and prospective economic efficiency of the proposed mining technology for low-thickness coal seams are carried out in case of one typical longwall face taking into account the mined rock transportation cost to coal-preparation plant and its enrichment, reducing the cost of mine working supports. Its technology is by 17% more cost effective, than traditional mining technology while rough coal ash content does not exceed 21%.

Key words: longwall operations, mining and geological thickness, wall rock undercut, coal ash, selective mining, waste rock placement, waste rock flow

Новий підхід до створення прогресивної та маловідходної технології відпрацювання малопотужних вугільних пластів

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Анотація. У даній статті детально поставлена проблема розробки малопотужних вугільних пластів Західного Донбасу, аналізуються технологічні, економічні та екологічні причини, що знижують ефективність традиційних технологій з повним обваленням порід покрівлі у виробленому просторі їх розробки, і пропонується новий прогресивний підхід її рішення. Акцентовано увагу на важливості кам'яного вугілля для енергонезалежності України та малої потужності вугільних пластів, який є найменшим показником серед вугільних родовищ, що експлуатуються в розвинених країнах світу. Показана ключова роль шахт Західного Донбасу в розвитку вугледобувної галузі України, де більше 50% припадає на пласти з геологічною потужністю від 0.55 – 0.80 м, що призводить до засмічення вугілля і подальших витрат на збагачення. Встановлено взаємозв'язок геологічної потужності пластів, що виймаються, і присічки бічних порід, а також виявлена десятирічна тенденція збільшення розмірів прісічок вміщуючих порід, що закономірно корелюється із загальною тенденцією зниження геологічної потужності пластів і призводить до збільшення середньої зольності видобутої гірничої маси. Виявлено джерела та визначено обсяги руху породних потоків з вугільної шахти до поверхні, 80 – 90% яких становить проведення підземних гірничих виробок і присічка вміщуючих порід при очисних роботах. Показано негативний вплив застосовуваних технологій відпрацювання тонких пластів, в результаті чого діючі породні відвали додатково поповнюються щороку на 3.0 – 3.5 млн т крупнокусковими

вуглевідходами збагачення й високовитратно транспортуються назад на породні відвали. Визначено, що 3 породних відвала розміщені біля населених пунктів, що здорожує екологічну плату за їх розміщення в 3 рази. Запропоновано новий підхід селективного відпрацювання тонких пластів із залишенням порід присічки у виробленому просторі лав, який відрізняється доповненням до секції механізованого кріплення горизонтально-замкнутого скребкового закладного конвеєра з трамбуючим пристроєм для ущільнення порід, що скорочує загальношахтний вихід порід на 25 – 30%. Проведено попередні розрахунки параметрів та очікуваної економічної ефективності запропонованої технології відпрацювання тонких вугільних пластів для одного середньостатистичного очисного вибою з урахуванням витрат на транспортування гірничої маси на збагачувальну фабрику та її збагачення, зниження витрат на повторне використання виїмкових виробок, яка на 17% економічніше в порівнянні з традиційною технологією відпрацювання пластів з повним обваленням порід покрівлі у виробленому просторі, при цьому зольність видобутої гірничої маси не перевищить 21%.

Ключові слова: очисні роботи, геологічна потужність, присікання порід, зольність вугілля, роздільне виймання, залишення порід, породні потоки

Introduction. Coal is a strategic type of mineral for Ukraine, capable of providing a significant part of energy independence at the current level of its development since thermal power plants (TTP) produce 37% of all electricity (Amosha, 2013; Snihur, Malashkevych, & Vvedenska, 2016; Mykhailov & Hrinchenko, 2018). The particular value for the energy sector is G black coal (gas-coal) because most of the TTP's energy production boilers are equipped specifically for this type of coal. The issue of developing new sources of energy resources is open and relevant (Bondarenko, Ganushevych, Sai, & Tyshchenko, 2011; Butyrskyi et al., 2019). However, the transformation of Ukrainian energy sector, which would meet the modern trends of developed countries, is proceeding rather slowly due to the predominance of the agro-industrial model of the economy.

world reserves) or 27.1 billion tons in seams with a thickness less than 1.0 m (Fig. 1). It is the lowest indicator among coal deposits exploited in developed countries (Ukraine coal, 2013; International Energy Agency, 2017). The presence of low-thickness coal seams in the composition of industrial reserves makes the further functioning of coal mines significant for the energy sector irrational due to the sharp increase in the mining process cost.

The problem of coal mining from low-thickness seams stay is particularly acute at the Western Donbas mines included into the part of the PJSC "DTEK Pavlohradvuhillia" which currently occupies a key role in the development of Ukrainian coal mining industry and state economy (Pavlenko, Salli, Bondarenko, Dychkovskiy, & Piwniak, 2007; Petlovanyi, Lozynskyi, Saik, & Sai, 2018). The geological data analy-

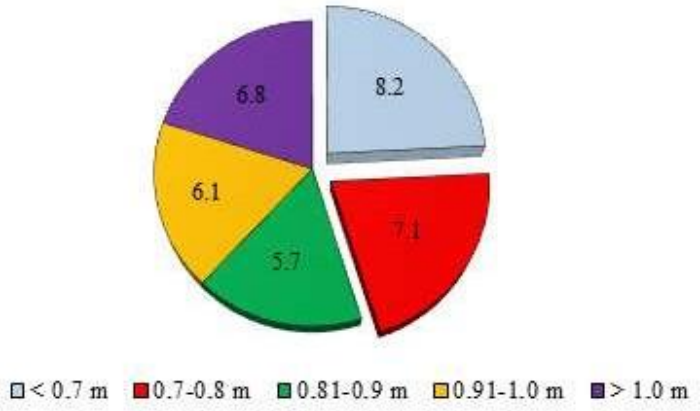

Fig. 1. Distribution of recoverable coal reserves by thickness (billion tons)

In all of the most important world coal deposits, there is a noticeable tendency of reduction the developed coal seam thickness and increasing in the intensification of mining operations in low-thickness seams that is also typically for Ukraine. Worldwide coal reserves account 861 billion tons whereof 194.5 billion tons or 22.6% are concentrated in coal seams with thickness less than 1.2 m. Ukrainian bowels concentrate 33.9 billion tons of coal (4% of

sis shows that more than 50% of 775 million tons of industrial reserves are present in seams with the geological thickness of 0.55 – 0.80 m and only 3% or 23 million tons of coal is bedded in seams with a thickness of more than 1.0 m that significantly limits the operational life of many mines in the region.

Thus, due to the mining completion of coal reserves in seams with a thickness of more than 0.80 m, it is planned to close 3 amongst 10 operating mines

in this region during the following 2 – 3 years. Using the traditional technology of mechanized mining of low-thickness seams (bulk mining with full roof caving behind the longwall face), there is an increase in extracted coal ash content and the volume of waste rocks accumulation. Costs and loads on equipment in the integrated technological scheme of mining operations increase significantly: the load on underground and surface transport, mine hoisting, rough coal processing with a return of large-sized rock fragmentations to waste dumps.

Recently, the relevance of developing technologies allowing to create highly efficient, low-waste and environmentally friendly production while mining of mineral deposits has been growing in the world (Lozynskyi et al., 2018; Zhang & Xu, 2018). For the coal mining industry, the development of such technologies is one of the most important, as its production activities adversely affect the natural environment. One of the most important reasons for its deterioration is the accumulation of rock dumps in the mining allotment of coal mines, which occupy valuable land areas (Gorova, Pavlychenko, Kulyna, & Shkremetko, 2012; Petlovanyi et al., 2019; Pactwa, Woźniak, & Dudek, 2020). In foreign developed countries, which have thick and extra-thick coal seams bedding in their bowels, mining operations are carried out with gob backfilling. Accumulated waste rock from dumps is used as filling material to prevent dangerous deformations of the Earth's surface (Jiang, Cao, Huang, Fang, & Li, 2015; Wang & Tu, 2015; Zhang et al., 2019). The application of mining technologies with backfilling is also widespread during the development of ore deposits (Emad, Vennes, Mitri, & Kelly, 2014; Kuzmenko & Petlovanyi, 2015).

The technological and environmental difficulties of low-thickness seams treatment raise an urgent issue of a radical revision of traditional technologies and existing approaches to the extraction of coal from thin coal seams and the creation of new ones with a higher level of economic and environmental efficiency.

This article analyzes in detail the reasons that reduce the efficiency of mining low-thickness coal seams in the Western Donbas that lead to the additional waste formation on the surface. The technological features and advantages of the new approach to coal mining in difficult geological conditions are considered, which significantly reduces the level of waste rock formation by accumulating them in the mined out underground space.

Features of mining low-thickness seams in the Western Donbas. The Western Donbas occupies a special place in the energy supply of the Ukrainian industry. The territory has 7.2 billion tons of coal or 21.3% of the country's total reserves. Annually mines produce 60% of Ukrainian coal (Barabash & Cherednichenko, 2015). More than 80% of coal reserves are concentrated in seams with a thickness of less than 1.0 m, while more productive reserves with relatively favorable conditions have already been worked out or practically depleted in the minefields of coal mines.

Currently, mechanized complexes of the following types KD-80, KD-90, KD-99, DM with shearers KA-90, KA-200, UKD 200-500 are equipped in longwall stoppings. Equipment is designed to operate in the range of mining thickness of 1.05 – 1.25 m (Hrinov & Khorolskyi, 2018; Petlovanyi, Lozynskyi, Saik, & Sai, 2018). Therefore, with an average geological thickness of 0.82 m, the size of wall rock undercut (the difference between the mining and geological thickness) is 0.23 m. It leads to an increase in the mined coal ash content and the formation of additional waste volumes after processing. Clogging of mined minerals with waste rocks negatively affects the technical and economic indicators of mines (Khoyutanov & Gavrilov, 2018; Petlovanyi, Lozynskyi, Zubko, Saik, & Sai, 2019; Petlovanyi & Ruskykh, 2019).

The aforementioned longwall mining equipment, in the conditions of Western Donbas, is not able to mine coal seams with thickness less than 1.05 m without wall rock undercut. It is due to the dimensioning specifications of mechanized complexes and the necessary height of free passage along the longwall face for maintenance personnel. Therefore, the wall rock undercut in longwall faces is a necessary measure during mining very thin coal seams. The generally accepted minimal mining thickness of coal seams is 1.05 m. However, in many cases mining thickness is increased up to 1.1 – 1.15 m for the safe operation of the mechanized complex in difficult conditions with high rock pressure and preventing the support sections from sinking on a "rigid" base. The relationship between the mining, geological thickness und sizes of wall rock undercut is illustrated on the Fig. 2, where technological schemes of coal mining at "Zakhidno-Donbaska" and "Heroiv Kosmosu" mines are presented.

Analysis of the Fig. 2 shows that with equal general accepted mining thickness of coal seams 1.05 m, the size of wall rock undercut of coal seam C_{10}^{t} is 0.06 m, and C_{11} is 0.20 m. This aspect contributes to a mixing of loosened coal with the rock, the deterioration of its quality characteristics and the emergence of additional costs for transport and enrichment. Thus, the average rough coal ash content among the

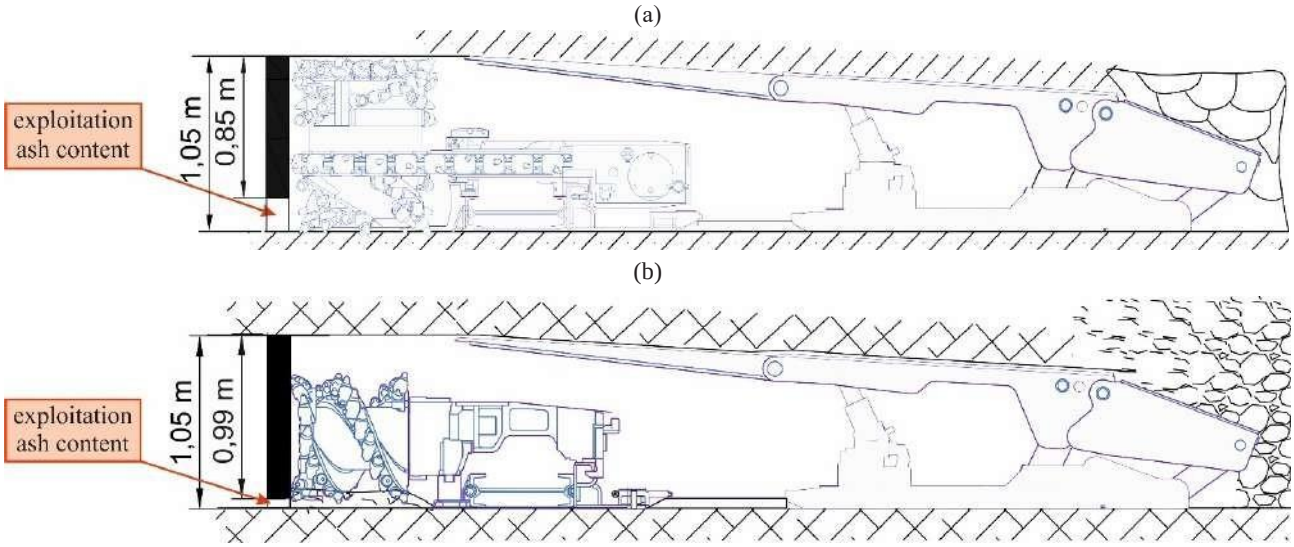

Fig. 2. Typical sections of longwall face with wall rock undercut: during C_{10}^{t} coal seam mining at "Zakhidno-Donbaska" mine (a) and C_{11} coal seam mining at "Heroiv Kosmosu" mine (b)

Western Donbas mines was 43.5% in 2018 (+ 6.7% compared to 2008). The most clogging of mined coal was observed at mines: "Heroiv Kosmosu" – 50.0%, "Samarska" – 47.0%, "Blahodatna" – 45.1%, "Zakhidno-Donbaska" – 40.5%. At the same time, there is a tendency to increase the mined coal ash content and respectively processing waste formation on the surface.

Processing and systematization of statistical production data of mining and geological thickness, the amount of wall rock undercut and coal ash content of the Western Donbas mines over a period of 2007 – 2018 allowed to identify important trends in these indicators (Fig. 3).

The Fig. 3 shows the tendency of steadily increasing the size of wall rock undercut. Thus, the average sizes of the wall rock undercut increased from 0.17 to 0.24 m for the considered period. In the range of geological thickness of mined coal seams of the West Donbas, the sizes of wall rock undercut changed from 0.06 m on the coal seams of more than 1.0 m to 0.44 m less than 0.70 m. At the same time, the mining thickness fits with the geological one only in 12% of longwall faces.

Studies of mining and geological statistics in the longwall faces of the PJSC "DTEK Pavlohradvuhillia" show that the average annual geological thickness of mining coal seams has decreased from 0.95 to 0.82 m (–0.13 m) over the past 10 years. It is accordingly entailed an increase in the produced coal ash content. The diagram pattern of produced coal ash content shows that rock hoisting has increased by 14% over

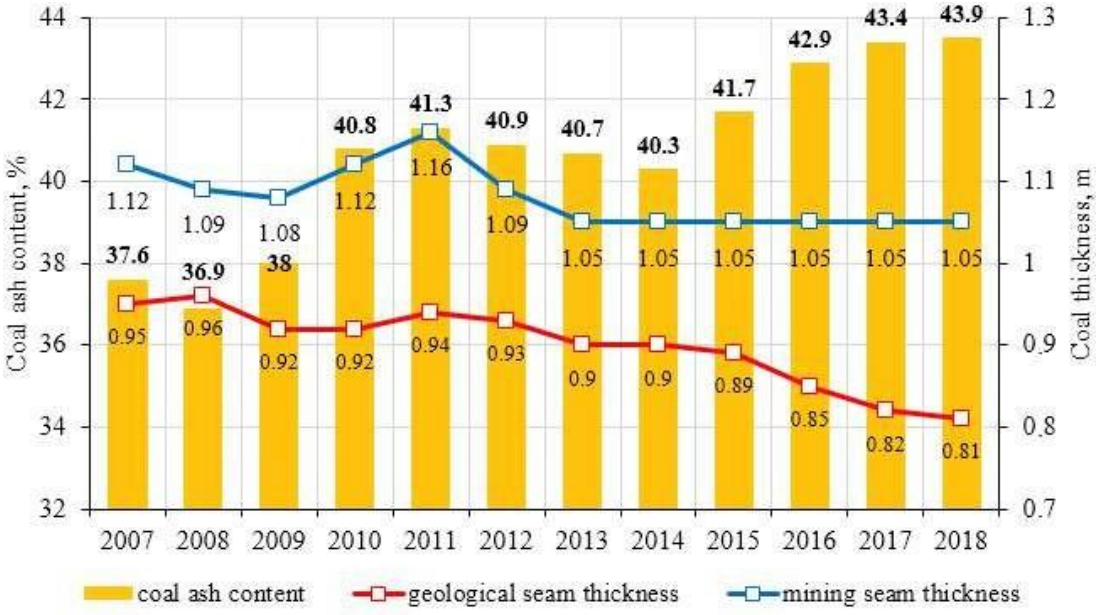

Fig. 3. Dynamic pattern of changing of geological thickness, sizes of wall rock undercut and produced coal ash content of the Western Donbas mines

the past 10 years. In 2018 mined coal ash content for some enterprises varied from 38.3 to 48.5% or 43.3% on average. At the same time, there is a tendency to increase the mined coal ash content and increase the coal waste accumulation on the surface.

Therefore, the issue of reducing the volume of hoisting rock from mines is particularly acute. The urgent need for its solution is dictated by both technical and economic requirements, and emerging environmental risks (Horban, Hornyk, & Kravchenko, 2019; Khorolskyi, Hrinov, Mamaikin, & Demchenko, 2019).

Analysis of the sources of formation and accumulation of coal waste during mining low-thickness seams in the Western Donbas. Waste rock is a reject of coal mining process stored in dumps usually near mines. Waste mine rocks belong to the IV waste hazard category and indicate their insignificant impact on the environment. The main environmental and economic aspects of the storage of rocks are the alienation of valuable land suitable for agricultural use, and the payment the fee by mining enterprises for the placement of 1 ton of waste, and when dumps are located near cities, the fee increases by 3 times.

A detailed analysis of coal mining technology shows that, depending on the processes of underground mining, a certain movement of the waste rock flow from the underground space to the surface is formed. The waste rocks of the Western Donbas mines are mainly contained siltstones – 50%, mudstones – 40% and sandstones – 10%.

In quantitative equivalents identified sources of mine rock input for the conditions of the Western Donbas mines based on the analysis of statistical information on the volumes of coal production, indicators of the total mine ash, analysis of the structure of the mining thickness (sizes of false roof and wall rock undercut), the volumes of mine workings and footwalling (Fig.4).

while longwall operations caused by the low geological thickness of coal seam (80 – 90% of total volumes of waste rock hoisting). It is practically impossible to prevent or reduce volumes of waste rock output from underground mine drivage under existing technological schemes. In the alternative, there is the experience of reducing volumes of wall rock undercut from longwall operations and gob backfilling (Koshka, Yavors'kyy, & Malashkevych, 2014). However, it did not find a wide application in the coal mining industry for a number of technological reasons.

Annually waste dumps of the coal mines in the Western Donbas are replenished by approximately equal volumes of rocks from mine working drivage (3.0 – 3.5 million tons). At the same time, there is the tendency of constantly increasing accumulation of waste rocks from wall undercut in longwall faces. Thus, mines produced a record amount of coal in the region – 20.0 million tons and wastes from coal processing plants – 4.6 million tons in 2018. At the same time, the volume of stockpiled rock in the waste dumps over the past 10 years has increased by 51% (Fig. 5), which naturally correlates with the general tendency of geological thickness decrease. These aspects show the current topicality of rock accumulation in underground spaces and creating new approaches for low-thickness coal seam mining.

Waste disposal sites (WDS) registry analysis of the Dnipropetrovsk region using the program Google Earth Pro 7.3.2 allowed to establish accumulation volumes, occupied areas and locations of coal wastes in Western Donbas (Fig. 6). In the Western Donbas there are 11 waste dumps formed during the period of industrial development of coal reserves. More than 100 million tons of waste rocks were accumulated with a total area of more than 200 ha. For example, in the territories of closed mine "Pershotravneva" and operating mines "M.I. Stashkova", "Dniprovska", "Samarska", "Ternivska", "Zakhidno-Donbaska" one waste dump

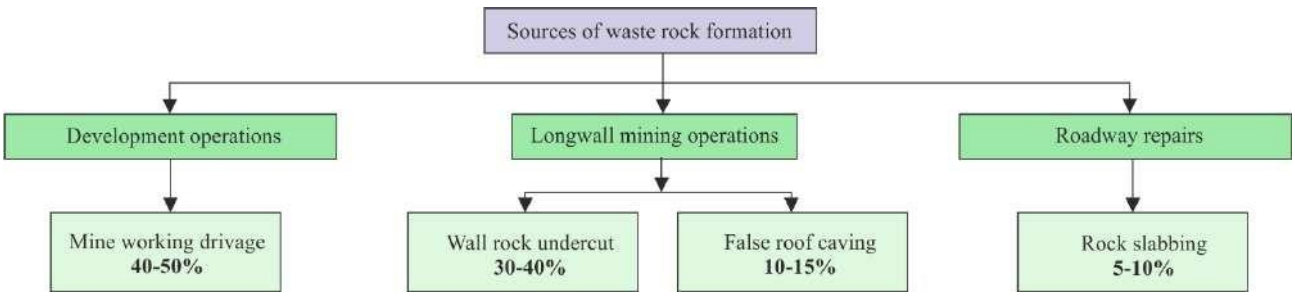

Fig. 4. The structure of waste rock flow while mining very thin coal seams in the Western Donbas

Analysis of the Fig. 4 shows that the largest volumes of movement waste rock flow are accounted for underground mine workings and wall rock undercut

is located. The rest of Western Donbas mines have two exploited waste dumps in the limits of mine allotments. All dumps have a flat plan shape (Petlovanyi

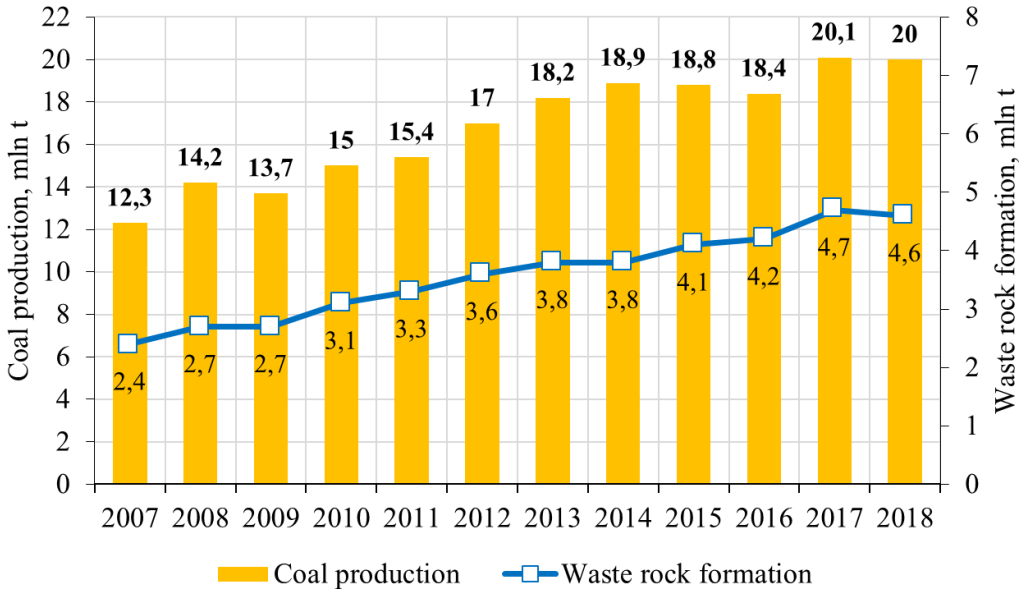

Fig. 5. Dynamics of coal production and additional formation of waste rocks in the Western Donbas conditions

& Medianyk, 2018). Moreover, there are three waste dumps located at a distance of less than three km from settlements. It is three times more expensive ecological payment for the placement of rocks.

It should be noted that 5 – 7 times larger area of lands suitable for agricultural use should be allocated for flat dumps compared to conical dumps. Therefore, from the environmental protection point of view, the waste rock accumulation requires reduction. The volumes of accumulated rock use are insignificant. It is mainly used for road constructions and tamponage of mine workings. It has been proven that waste dumps are sources of valuable mineral raw materials, and waste rocks are a significant resource for construction industry (Bini, Maleci, & Wahsha, 2017; Lèbre, Corder, & Golev, 2017).

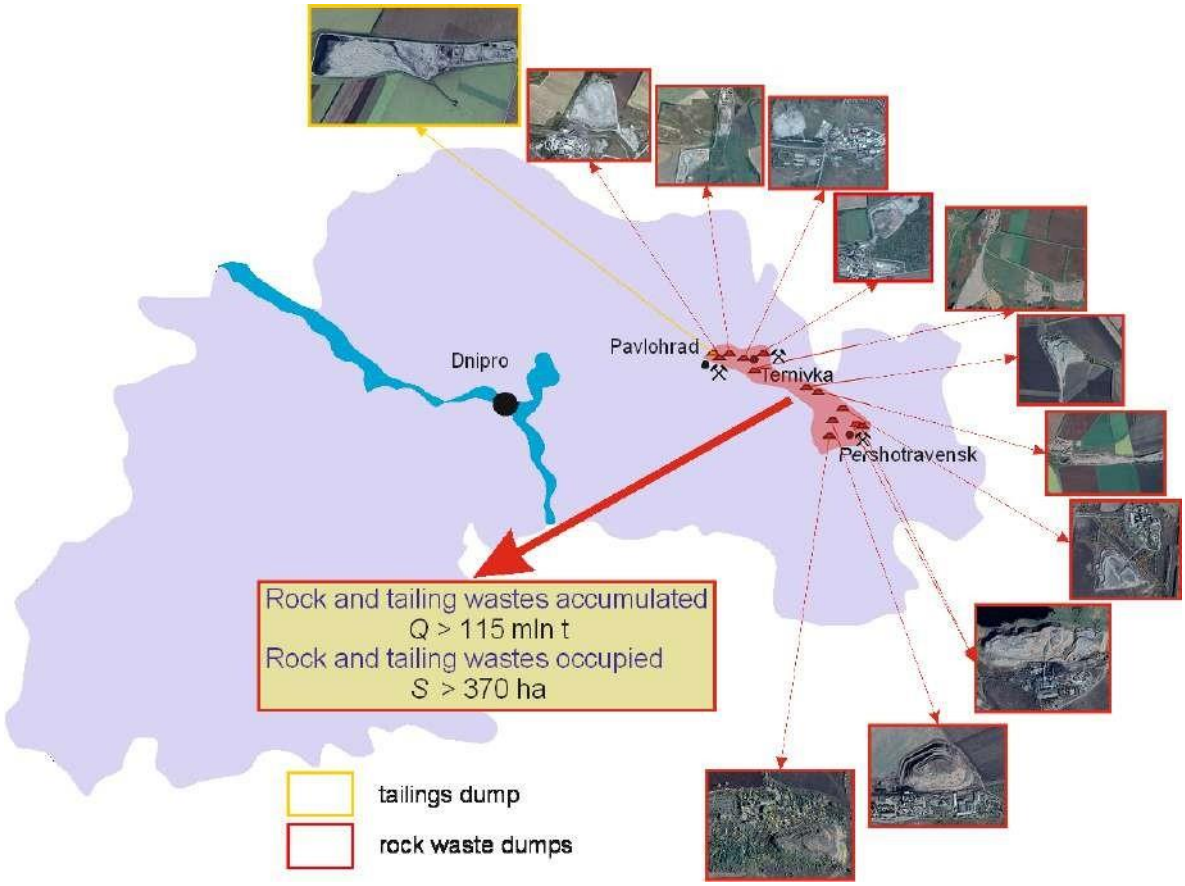

Fig. 6. Accumulation of mine waste dumps and their location in Western Donbas

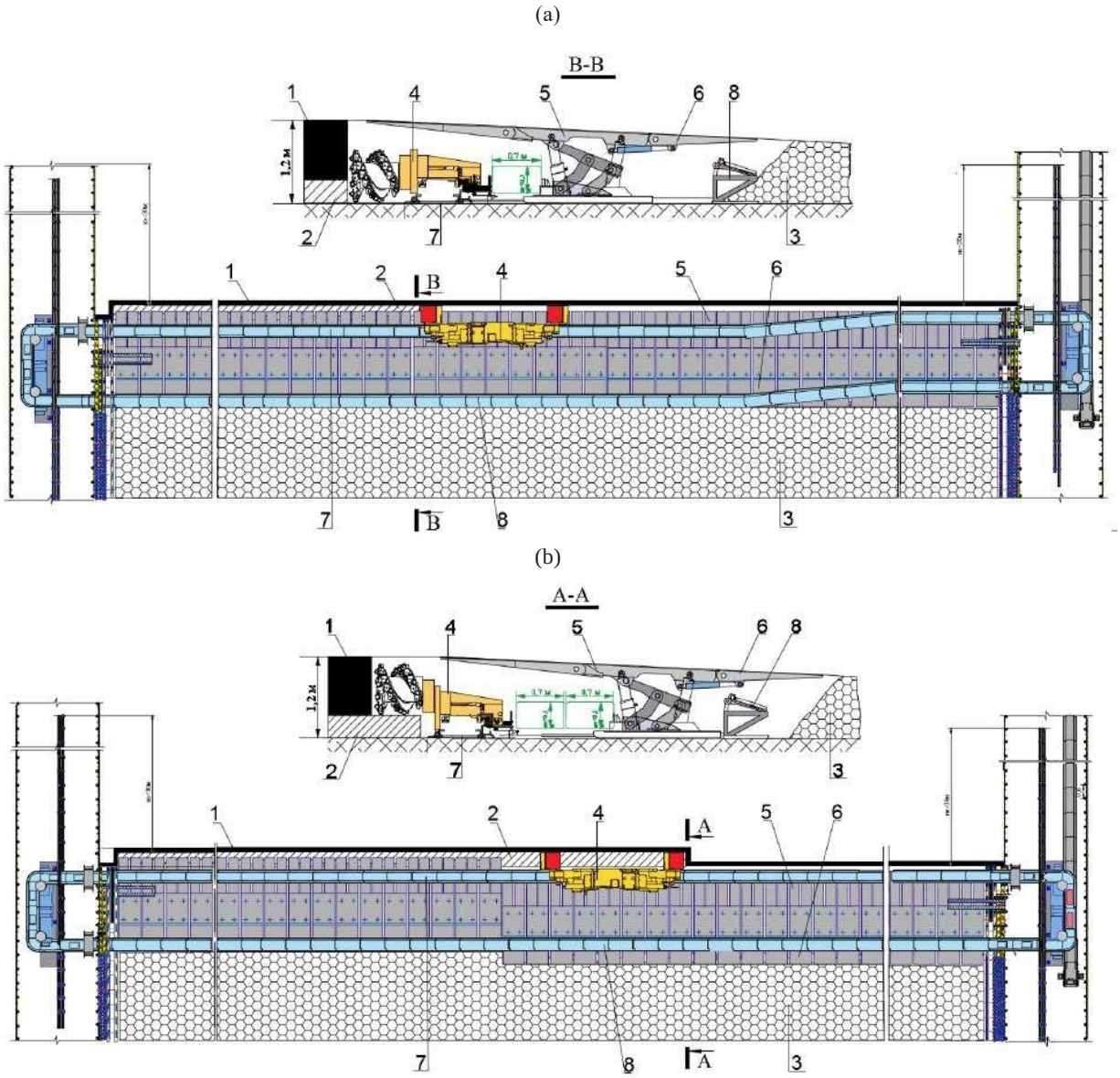

Fig. 7. The technological scheme of selective mining of very thin coal seam with rock placement: (a) coal extraction; (b) rock extraction and placement; 1 – coal seam; 2 – wall rock undercut; 6 – reverse cantilever of mechanized support, 7 and 8 – corresponding face and backfilling lines of horizontally-closed scraper conveyor

The central processing plant "Pavlohradska" operates in the region with an annual capacity of 6 million tons. The ash content of extracted coal reduced to the established quality standards of TTPs to the level of 23 – 24%. Wet fine coal wastes are stored in the tailings pond of 170 ha, and large-sized separated rock is returned to waste dumps nearby coal mines by heavy trucks. This fact testifies to the high costs of circulation of rock streams in the system "coal mine – processing plant".

Features of creating the technological scheme for selective mining of very thin coal seams. In the late 1990s, an attempt was made to create innovative technology for the selective mining of low-thickness coal seams with gob backfilling, but this technology did not receive further application (Byzylo, Koshka, Poymanov, & Malashkevych, 2015). The technology involved selective mining of coal seams with further mined out space backfill by pneumatic complex "Titan" located behind the longwall face in the mine drift. Brocken rock after shearer passing along the rock wall rock bench was transported to the backfilling pneumatic complex "Titan" where it was crushed and passed through the pipeline into the gob. The low productivity of longwall operations, the high dustiness along with the clogging of mine drift and the difficulty in performing tail operations were the main reasons for technology refusal.

Under current conditions and tendencies of coal mining industry development, the problem of low-thickness coal seam mining can be solved due to the introduction of selective mining of very thin coal seams

and wall rock undercut with their subsequent placement in gob using new technological units in the mechanized complex that eliminate the disadvantages of the above technology (Bondarenko & Malashkevych, 2019). The technology involves coal seam mining with a thickness of 0.55 – 0.80 m, the subsequent extraction of wall rock undercut with a height of 0.40 – 0.65 m and placement it in the gob. Fig. 7 shows the technological scheme of selective mining of very thin coal seam with rock placement in the gob.

The mechanized complex includes the shearer MB-280E, the modernized mechanized support 1MKD-90 with an elongated face cantilever on 375 mm and the reverse shield with a length of 1500 mm. Transportation of coal and rock is carried out by the horizontally-closed scraper conveyor (Fig. 8).

The process of coal extraction is carried out in the following way. The support and the conveyor stand close to the face in the initial position. The section of the mechanized support is unfastened. The conveyor drive heads are shift. The shearer is cut into the coal seam at the ventilation drift. The forward drum is installed in the upper position and maintained by a seam roof, the back drum is maintained on the extraction of leaving rock bench. When the shearer moves from ventilation to conveyor drift the coal is removed without wall rock undercut. When the shearer moves in the opposite direction the section of the support is alternately moved, at the same time the face and backfilled conveyor lines are not moved.

The process of rock extraction and placement it in the worked-out space is performed as follows. After the extraction of coal and its transportation to the conveyor drift, the shearer is reversed. Further, the rock bench is extracted in the direction from conveyor to ventilation drift. The rock is transported from the face to the conveyor drift, and then it goes around the drift and, in the opposite direction, enters on the backfilling conveyor line of the horizontally closed scraper conveyor.

The backfilling line of the conveyor is installed at an angle to the seam floor plane. As the crushed rock moves along the inclined pans, it is self-unloading into the worked-out space with its subsequent packing by a tamping device. The laying of the backfilled massif is carried out continuously along the length of the worked-out space. The technology provides placing in mined-out space wall rock undercut and reducing waste hoisting by 25 – 30%.

Rock placement in mined-out space has a positive effect on the reduction of the stress state of coal-bearing massif as well as surrounding rock massif excavation mine workings allowing them to be reused (Kononenko, Petlovanyi, & Zubko, 2015; Malashkevych, Sotskov, Medyanyk, & Prykhodchenko, 2018).

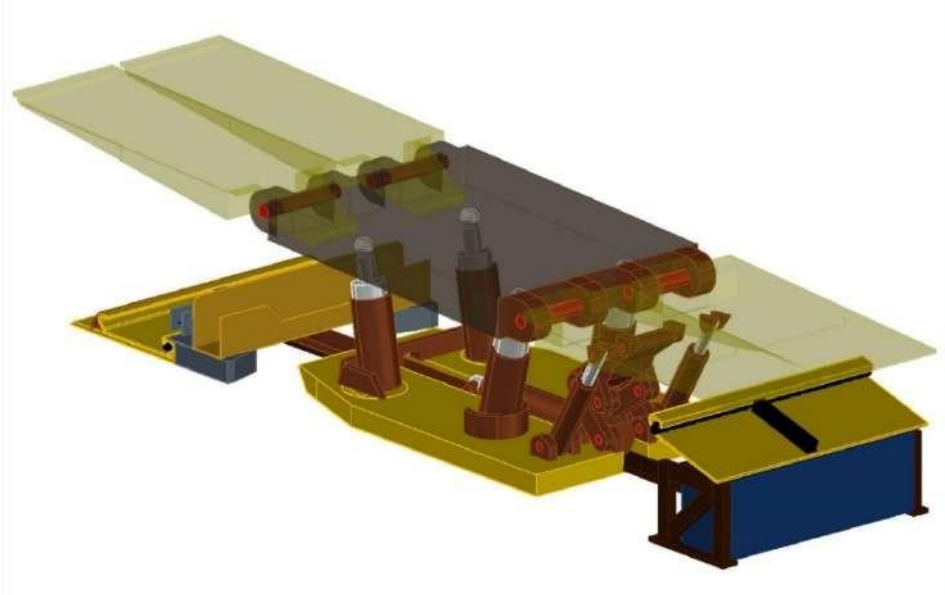

Fig. 8. Overall view of mechanized roof support and horizontally-closed scraper conveyor

The expected main technological parameters of the selective mining technology are pre-determined on the example of the mine "Ternivske" PJSC "DTEK Pavlohradvuhillia" conditions. Thus, the expected production output is 966 t/day at coal seam thickness of 0.55 m and 1314 t/day of clean coal at 0.80 m respectively. At the same time, the ash content of the produced coal in the range of the geological thickness of the seam 0.55 – 0.80 m varies insignificantly from 19.6% to 21.1% (with maternal A_d = 12.3%). The charts of the dependency graph per of the face output and the ash content of the extracted coal on the wall rock undercut values are shown in Fig. 9.

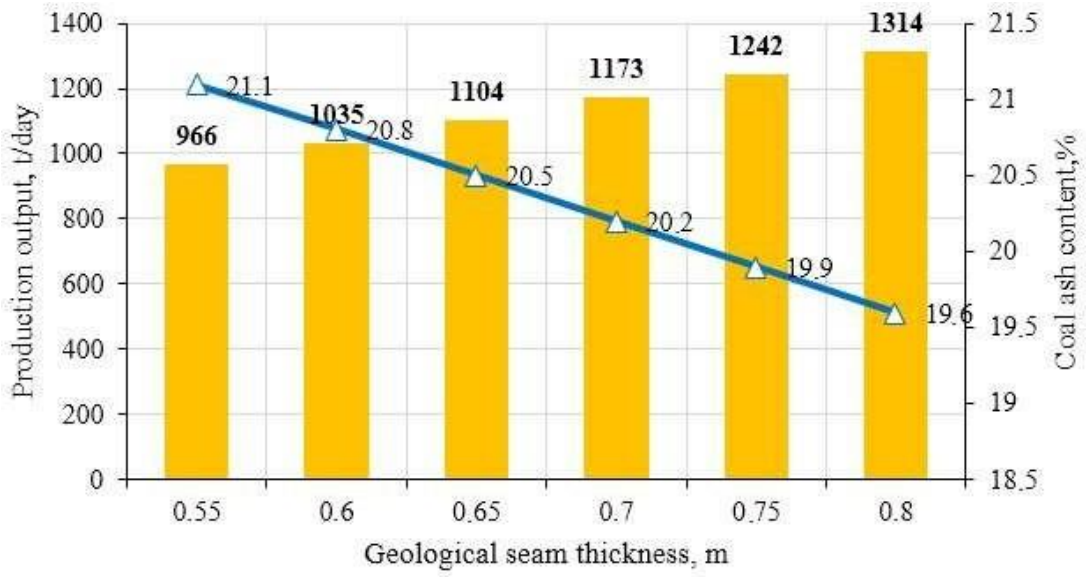

Fig. 9. The chart of the dependence of the face output and ash content of the extracted coal on the wall rock undercut values

To assess the economic efficiency of the application of selective coal mining technology, calculations were carried out with 2600 m longwall panel length and 250 m width, 1.05 m mining coal seam thickness and 0.70 m geological seam thickness. The end-use consumer is the TTP. The expected annual coal production will be 330 thousand tons; daily output will be 1120 tons; the amount of abandoned rocks in the mined-out space will be 310 thousand tons /year; ash content of mined coal will be 21%. The main economic indicators are presented in the Table 1.

Table 1. The main expected economic indicators of technology

Indicators	million **USD**	Indicators	million **USD**
Revenue	17.01	IC	71.5
OPEX	–5.27	NPV	58.6
EBITDA	11.73	PLC	10.0
Net profit	7.78	DPP	4.3
CAPEX with VAT	57.48	IRR	15.6
Working capital	6.18	ROI	15%

Based on the data achieved performance of the technology. The net profit from coal sale will be 7.78 million USD annually, which is 17% more than using the existing traditional technology, providing a gross excavation of coal with the cutting of surrounding rocks and the enrichment of contaminated rock mass on the surface. The obtained results are achieved due to almost two times reduction of the cost of transporting the rock mass to the processing plant and its enrichment, reducing the costs of re-using the excavation mine workings. Therefore, the preliminary economic calculations show that technology is progressive, as it provides growth in production indicators and improves the ecology of mining. The proposed technical solutions are at the pre-project stage of the development.

Conclusions. The progressive and low-waste technology of low-thickness coal seam mining is proposed in this article. The detailed study of current trends in the development of Ukraine coal mining industry, geological features of coal reserves occurrence, applied mining technologies is carried out. The relations of mining, geological thickness, and wall rock undercut height leading to the accumulation of large-scale waste of processing plants are identified.

In the course of the performed researches, several features and results were revealed:

– the Western Donbas mines play a key role in the development of Ukrainian coal mining industry (60%), where the PJSC "DTEK Pavlohradvuhillia" operates. Despite the achieved positive results, there is a problem of coal production from low-thickness coal reserves. More than 50% of 775 million tons of industrial reserves are coal seams with a thickness of 0.55 – 0.80 m. It is the main cause of coal clogging;

– the tendency of a steady increase in the sizes of surrounding rock undercut is determined. Wall rock

undercut in the longwall faces of the Western Donbas mines has increased from 0.17 to 0.24 m for ten years. It has led to an increase in the average ash content of the extracted coal from 36.8 to 43.5%;

– the sources and volumes of waste rock are identified. The key places in waste rock formation are occupied by mine working drivage and undercuts while longwall operations caused by the low geological thickness. It makes up 80 – 90% of all rock flow from coal mines;

– during the development of coal reserves in the Western Donbas 11 waste dumps and 1 tailing were formed. Their volumes are more than 115 million tons located on 370 ha of valuable lands, whereof 3 waste dumps located at a distance of less than 3 km from settlements that in 3 times more expensive environmental fee for the placement of rocks;

– the technology of selective (separate) extraction of very thin coal seams and wall rock undercut with their subsequent placement in the mined-out space with the use of new technological units is presented. It is proposed to use horizontally-closed scraper backfilling conveyor with a tamping device as the part of the mechanized complex that leads to the reduction of waste rock hoisting by 25 – 30%;

– preliminary calculations of technological parameters and expected economic efficiency have shown that proposed technology is more cost effective than the existing traditional one by 17% due to almost 2 times reduction of the cost of transportation of the rock mass to the processing plant and its enrichment, as well as reducing costs re-use of excavation works.

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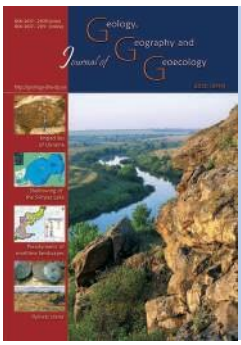

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Problems of technical exploitation and ecological safety of hydrotechnical facilities of irrigation systems

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Abstract. In this work, we analyzed and studied the Ukrainian typical hydrotechnical structures of the ameliorative complex on soil materials. On the examples of such objects in Dnipropetrovsk oblast, we carried out research and determined the technical condition of the transporting (main irrigation canals) and regulating (retention ponds) hydrotechnical structures (HTS). The main factors and the reasons for the negative engineering-geological processes occurring in those structures and affecting the ecological balance of adjacent territories were determined. The study revealed that the long period of exploitation and absence of corresponding technical care have led to significant losses of irrigation water from the canals and retention ponds. Due to the systemic absence and low use of monitoring researchers, we have proposed the use of prompt and low-cost methods and means of technical diagnostics. The article presents the possibility of using a complex of geophysical methods of natural impulse magnetic field of the Earth and vertical electrical sounding for the purposes of technical diagnostics. The possibility of recording plots and parameters of zones of seepage deformations in the body and at the base of the structures was visually determined and instrumentally proven. This allows identifying the amounts of technical and material resources, stages and order of implementation of repair-restoration works. It was determined that share of the damaged zones accounts for 20 to 35% of the total length of the hydrotechnical structures depending on their type and parameters of the constructions. In such conditions, the estimated losses of water equal 17-22% of the total amount of the delivery. The surveys showed that further operation of HC poses an ecological threat because of significant worsening of quality of water resources. The article presents disturbing dynamics of change in the irrigated areas involving the danger of secondary salinization, sodification, alkalinization, and toxification as a result of watering. We indicated threatening changes in the structures of the areas irrigated with low-quality water, which, according to various indicators of danger, increased by 1.4 times regarding threat of secondary salinization and by 2 times regarding threat of sodification. We proposed and substantiated approaches to improving the general technical and technological level of functioning of ameliorative structures in the context of maintaining ecological balance and economic practicability of their further use, based on the principles of systemic optimization of complex technical-natural ecosystems.

Key words: hydrotechnical facility, irrigation canal, retention pond, technical condition, seeping losses, geophysical methods of survey

Проблеми технічної експлуатації та екологічної безпеки гідротехнічних споруд зрошувальних систем

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Анотація. В роботі розглянуті та досліджені типові для всього меліоративного комплексу України гідротехнічні споруди з ґрунтових матеріалів. На прикладі таких об'єктів у Дніпропетровській області, проведені дослідження та встановлено технічний стан транспортуючих (магістральні зрошувальні канали) і регулюючих (регулюючі басейни) гідротехнічних споруд (ГТС). Визначено основні фактори та причини негативних інженерно-геологічних процесів, які відбуваються в цих спорудах і чинять вплив на екологічну рівновагу прилеглих територій. Виявлено, що тривалий період експлуатації та відсутність належних технічних доглядів призводять до значних втрат поливної води з каналів і регулюючих басейнів. У зв'язку з системною відсутністю та низьким застосуванням моніторингових досліджень, запропоновано використання оперативних, достовірних та недорогих методів і засобів технічної діагностики. Представлена можливість застосування комплексу геофізичних

методів природного імпульсного електромагнітного поля Землі та вертикального електричного зондування для цілей технічної діагностики. Візуально встановлено та інструментально підтверджено можливість фіксації ділянок та параметрів зон фільтраційних деформацій в тілі й основі споруд. Це дозволяє визначити об'єми технічних та матеріальних ресурсів, етапність та черговість реалізації ремонтно-відновлювальних робіт. Встановлено, що частка порушених зон складає від 20 до 35% загальної протяжності гідротехнічних споруд залежно від їх типу і параметрів конструкції. За таких умов розрахункові втрати води сягають 17-22% від сумарного об'єму подачі. Показано, що подальша експлуатація ГТС є екологічно небезпечною внаслідок значного погіршення якості водних ресурсів. Наведено загрозливу динаміку зміни зрошуваних площ за небезпекою вторинного засолення, осолонцювання, підлуження та інтоксикації внаслідок поливу. Відзначено загрозливі зміни в структурі площ политих водою низької якості, які за різними ознаками небезпеки збільшились від 1,4 рази за небезпекою вторинного засолення до 2-х разів за небезпекою осолонцювання. Запропоновано та обґрунтовано підходи з підвищення загального технічного і технологічного рівня функціонуючих меліоративних споруд за умови збереження екологічної рівноваги і економічної доцільності їх подальшої експлуатації, які базуються на принципах системної оптимізації складних техно-природних екосистем.

Ключові слова: гідротехнічна споруда, зрошувальний канал, регулюючий басейн, технічний стан, фільтраційні втрати, геофізичні методи досліджень

Introduction. Implementation of a strategic direction of the development of the agricultural sphere regarding the use of water, energy and material resources is oriented towards increase in the agricultural production volumes. An integral constituent of the provision is the technical condition and ecological reliability of hydrotechnical structures (HTS) of the ameliorative complex.

One of the most developed regions of the country is Dnipropetrovsk Oblast located in the north-east part of Ukraine, in the basin of the middle and lower reaches of the Dnipro. The total area of the territory of the oblast is 3,129 thou ha, including 2,569 thou ha (82%) of agricultural fields.

According to the amount of atmospheric precipitations, Dnipropetrovsk Oblast belongs to the zone of unstable moisture. The average annual amount of precipitations is 465-553 mm. Variation of the distribution ranges from 227 mm in low moisture years to 900 mm in high moisture years.

In summer precipitations usually come as cloudbursts, thus, their beneficial use for vegetation of plants is low, and insufficient moistening of the upper (arable) layer of the soil creates unfavourable conditions for the agricultural production. Therefore, high and stable yields of agricultural crops require additional moistening, i.e. organizational and technological provision of irrigation of land.

In view of food security of the state, we should consider that relevant research which would help to obtain stable and high yields of agricultural crops should include that oriented towards further improvement and ensuring of the norms of the current level of exploitation of any complex technological-natural ecosystems, including land-ameliorative structures. For this purpose one must consider their ecological reliability and safety.

Analysis of literature data and description of the problem. In the historical aspect, the hydromeliorative measures, particularly irrigation, in Katerynoslav Governorate (now Dnipropetrovsk Oblast), began to be implemented in the early XX century, only after catastrophic crop failure in the southern part of what was then Russia.

Since 1880 the tsar's government organized a number of expeditions with the purpose of creating a corresponding scientific base for fighting droughts and crop failures. The results of these expeditions gave a specific impulse to the development of irrigated arable farming in Dnipropetrovsk Oblast (Shevelev et al., 2005). Already in 1917 the area of irrigated fields in the Oblast accounted for 110 ha.

In 1930-1933 the Seliansky irrigated site 1,200 ha in area, Kamensky irrigated site 1,300 ha in area, and the 600 ha irrigated plot on Khortytsia island were projected and constructed. In 1939, in Kamianka Kolkhoz in Sofiivka district, an irrigated site of 500 ha was constructed, where for the first time in Ukraine fixed position sprinkler machines were employed, - these machines inspired development of sprinkler machines Volzhanka and Dnipro (Regional office of water resources in Dnipropetrovsk region).

In 1941 the area of irrigated fields in Dnipropetrovsk Oblast equaled 10,222 ha. Tempi of constructions of irrigated areas increased, accounting for 19 thou ha in 1960, 64.2 thou ha in 1965, and 124 thou ha in 1970.

In the late 1980s and early 1990s, in the irrigated fields, far-reaching sprinkler machines were being used and the area of irrigated land in Dnipropetrovsk Oblast in 1990 reached 219.6 thou ha. In the future, the governing bodies of the state expected to increase the area of irrigated lands in the Oblast to 540 thou ha by the year 2000 as a result of construction of large irrigation systems withdrawing water from the Dnipro, Dnipro-Donbass, the Dnipro-Kryvy Rih, Dnipro-Inhulets canals and by using drainage water from settlements (Shevelev et all., 2005; Regional office of water resources in Dnipropetrovsk region).

Over the recent years, due to the difficult econom-

ic condition, construction of new irrigation systems has been stopped. Old objects are gradually going out of order. Only in separate farms is complete watering of agricultural crops carried out. In some cases, in absence of sprinkler equipment surface irrigation (mainly vegetable crops) is applied. At the same time the area under irrigation changes all the time (Fig. 1).

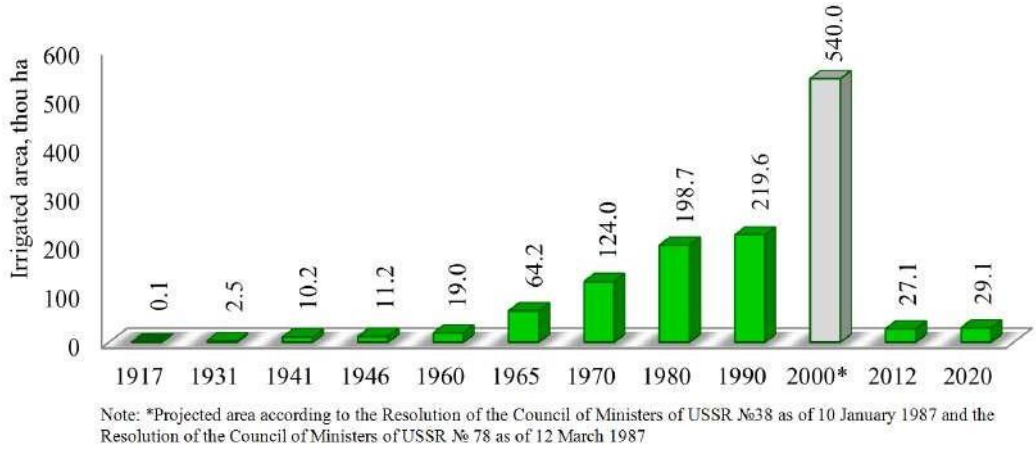


Fig. 1. Dynamics of changes in the irrigated areas in Dnipropetrovsk Oblast

The planned parameters of 540 thou ha under irrigation by the year 2000 were not achieved, instead more and more small systems of drip irrigation were built using water intake constructions and equipment of existing capacities. Gardens and vegetable crops are watered. At the same time, apart from irrigation, novel technologies of cultivation are used and such fertilizers and varieties are used which may significantly increase the efficiency of agricultural production and decrease the period until return on investments.

In terms of districts of the Oblas, the irrigated lands are arranged unevenly, primarily due to the presence of irrigation sources (Rudakov et all., 2019). Figure 2 depicts a schematic map of the oblast with the information on built and potential irrigation systems and their areas.

Currently, actually, the problematic issues of agricultural hydrotechnical land ameliorations in Ukraine have two main onward scientific vectors - the theoretical and the practical . The first is related to renovation of irrigation land-development, maintenance, recreation and rational use of fields and aquatic resources in the territory of our country (Ushkarenko et al., 2005; Vozhegova et al., 2013; Romashchenko et al., 2015, 2017). The second orientation is associated with the technical and technological component of the work of hydrotechnical facilities and land-development complexes. It is related to the assessment of technical condition, level of reliability and safety of exploitation of the objects. Global and domestic experiences indicate significant periods of work, deterioration of technical conditions and non-correspondence to the modern requirements of exploitation (Weyer et all., 2008; Huang et all., 2010; Shchedrin et all., 2011; Bedjaoui et all., 2011).

Projects of construction at some facilities include setting up designed control-measuring equipment, piezometers and monitoring drainage wells for the control of losses of water and level of groundwater in the zone of influence of HTF. In most cases these components of technical equipment are non-functioning or ruined. It should be noted that currently the instrumental methods of investigating such facilities in Ukraine are practically unused. Sometimes, episodically, surveys using electrometric methods of geophysics are performed (Litvinenko et all, 2009). The investigations are conducted on a small number of objects due to the high cost and labour-intensity entailed. At the same time, except for visually noticeable damaged areas, a significant amount of zones of deformation, suffosion, water saturation, formation of fractures are impossible to determine visually at the initial stages of their development. Hence, this situation indicates the practicability of performing diagnostics of technical condition applying contemporary methods and means of distant control.

Objectives and purposes of the study. The conducted surveys were oriented towards identifying the level of current technical exploitation of hydrotechnical facilities of irrigation systems and their influence on ecological-ameliorative condition of their location within Dnipropetrovsk Oblast. The main water-transporting and water-regulating facilities in the irrigation systems are open canals and regulatory basins which provide uninterrupted supply and accumulation of irrigation water for watering agricultural crops.

To achieve our goals we solved the following tasks:

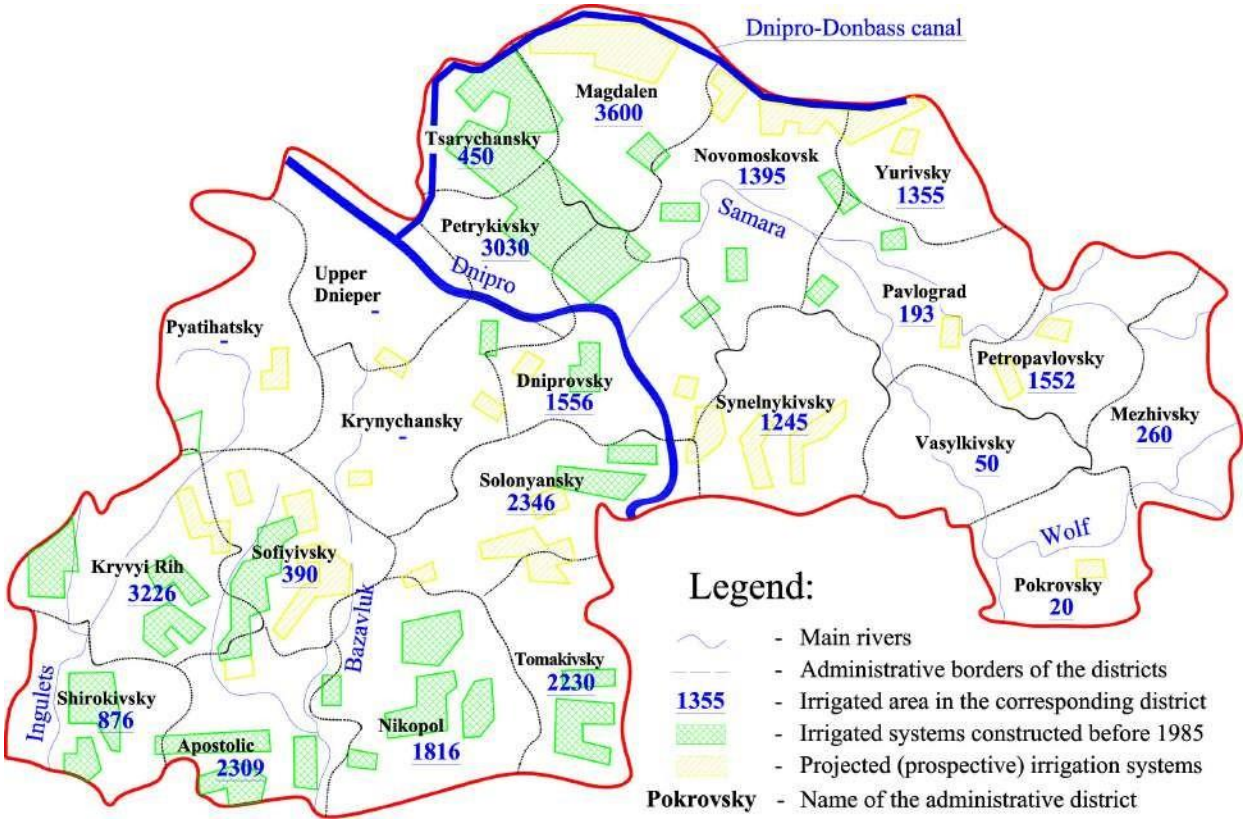


Fig. 2. Schematic location of irrigated areas in Dnipropetrovsk Oblast (developed by the authors using the materials (Duplyak et all, 1985)).

analyze the historical experience of creation and functioning of hydrotechnical facilities of ameliorative complexes in the territory of Dnipropetrovsk Oblast in different conditions of their operation;

determine the contemporary technical condition of hydrotechnical facilities by visual diagnostic monitoring using instrumental geophysical methods of surveys;

assess the geoecological influence on the adjacent territory, ecological reliability and safety of future exploitation of irrigation systems;

propose ways and approaches to ecologically-and-economically based improvement of technological level of functioning of the objects.

Materials and methods of surveys. The studies were conducted using the following methods: 1) visual diagnostic monitoring of bodies and the bases of the facilities; 2) field studies using complex of geophysical methods of Earth's natural pulse electromagnetic field (or ENPEMF) and vertical electric sounding (VES); 3) processing, analysis and generalization of the obtained results using mathematical methods and modern program complexes Microsoft Excel, AutoCad, Golden Software Surfer, IP2Win, Google Earth Pro.

The Earth's natural pulse electromagnetic field is one of the geoelectric fields. Methods and methodology of studying it began to be developed in the mid 1970s in the Tomsk Polytechnic State University under the leadership of O. A. Vorobiev. Since then the method has been introduced into geophysics under the name ENPEMF method. With time it has been improved, new methods and apparatus base have been developed, and the range of tasks it is capable of solving has been broadening. Contemporary devices allow us to perform various engineer-geological and hydrogeological surveys, determine zones of fractures and rupture damage, study and predict the development of shifts, etc (Pikarenya et al., 2009).

ENPEMF is characterized by non-stationary condition in any moment of time. Due to its wave nature, ENPEMF spreads in the Earth`s crust, but in the areas where fractures have formed, cavities appeared and became filled with fluid (water), the intensity of electromagnetic radiation (EMR) sharply decreases. Energy of EMR dissipates in gas or is absorbed by fluid. Because hydrotechnical facilities are made of soil materials, they are "transparent" for ENPEMF, but when fractures occur or soils become humid inside, the intensity of the field decreases. This reflects in decrease of density of the current of impulses of ENPEMF magnetic component, i.e. in the amount of impulses recorded during measurements (usually 0.5 – 1.0 sec). At the same time impulse is considered any excess of frequency-wave amplitude or energy of

ENPEMF over a certain determined level of discrimination (background value). Particularly the value of density of the flow of impulses is the basis for interpretation of studies adopting ENPEMF. Therefore, use of this method allows one to determine areas of seeping deformations and damaged zones on the bodies and bases of facilities.

Apparatus and equipment. Monitoring using ENPEMF was performed using a MIEMP-14/4 device (SIMEIIZ series) with simultaneous use of three antennae oriented length-wise, across and vertically downwards at the distance of 15-20 cm from the surface of the facility. Survey was performed using the following parameters of the device, similar for all antennae: frequency of discretization – 50 kHz, duration of measurement – 0.2 sec, coefficient of increase of signal – 10 V/mV, level of discrimination – 2 mV, measurement regime – simultaneous.

Substantiation of possibility and expedience of applying the ENPEMF method for the survey`s goals is described in-detail in the following studies (Orlinskaya et al., 2012; Hao et al., 2012; Wang et al., 2017; Kuzmenko et al., 2018; Chushkina et al., 2019). This method of geophysical studies is included in a number of state standards of Ukraine (Zbirnyk koshtorysnykh norm na heolohorozviduvalni roboty (ZUKN), 1999; Inzhenerni vyshukuvannia dlia budivnytstva, 2014).

The method of vertical electric sounding (VES) is one of the oldest methods of electric sounding, and therefore quite well=known and broadly used in geophysical practice. Its main advantage is simplicity of application and ostensible results, substantiating its active employment around the world. To carry out the studies using the VES method, we used standard electric-survey mine apparatus SERS 5 M (*Ukrainian* -ШЕРС 5 М). It has current A and B and measuring (reception) M and N electrodes (Fig. 3). As electrodes we used metal pins inserted into the ground. For installation of current and reception lines, we used steel-copper wires and cables. Electrodes were aligned in one line in relation to the center of the device.

The results of the studies using the VES method were analyzed using a special program IPI2Win developed by Bobechov O. A., which was created for automated and semi-automated interpretation of the data. This allowed us to obtain the depth of embedding of ground water and position of the water-resistant layer in the territories adjacent to the canals and basins. Further these data were used to determine quantitative parameters of losses of water from the irrigation systems and determine the level of waterlogging in the adjacent territory.

To calculate the seepage loss of water from the canals and regulating basins, we used classic generally-accepted methods (Vedernikov, 1939). Specific loss of water per 1 m of length of the seepage zone is determined using the formula:

$$q = k_f \cdot (B + A \cdot h_0) \cdot (1 + \frac{h_0 + h_k}{Y}), \quad (1)$$

where k_f – coefficient of seeping of soil of slope, m/24 h; B – length from the start of the slope to the point with stable level of groundwater, m; A – coefficient which takes into account side spilling of the seeping flow; h_0 – depth of water in the structure, m; h_k – height of capillary elevation, m); Y – depth to the water-resistant layer, m.

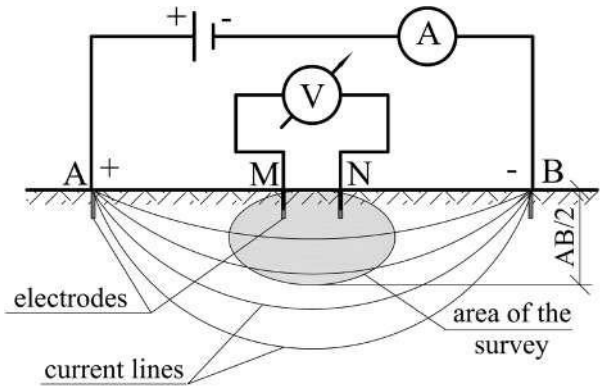
Ecological risks of waterlogging of the territory near the irrigation hydrotechnical facilities were predicted based on the standard methods (Ministry of Housing and Communal Services of Ukraine, 2010). Risk coefficient of waterlogging in this territory R was determined using the formula:

$$R=\lambda \cdot v, \quad (2)$$

where λ – coefficient of threat of waterlogging;

ν – coefficient of vulnerability to waterlogging.

Objects, conditions and methods of studies. Objects of the study were water-conveying (main canals) and water-regulating (retention ponds) hydrotechnical facilities made from soil materials which are the constituents of land-ameliorative complex. All surveys were performed within a day in favourable weather and climatic conditions. Field surveys were conducted on 3 main canals of Vyshchetarasivska, Soloniano-Tomakivska and Kilchenska irrigation systems (Tomakivsky, Soloniansky, Dniprovsky, Petrykivsky, Mahdalynivsky and Tsarychansky districts) and 10 retention ponds of the Petrovska (2), Soloniansko-Tomakivska (2), Vasylivska, Tsarychanska (3), Troiitska and Kalynivska irrigation systems. The first 5 basins are located in Soloniansky



Legend: *V* - voltmeter; *A* - ammetr; *AB* - reception electrodes; *MN* - current electrodes.

Fig. 3. Scheme of survey using VES

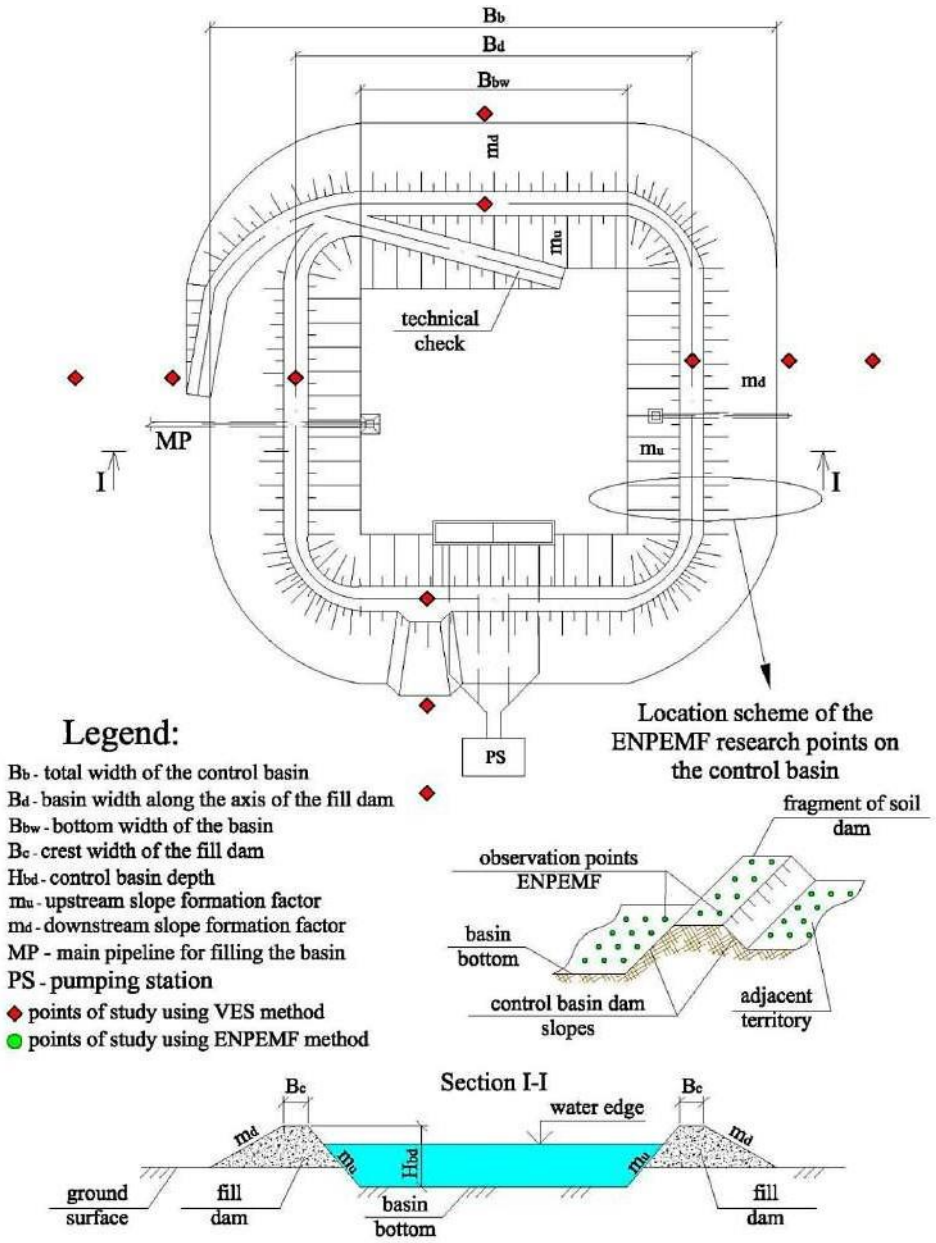


Fig. 4. Constructive scheme of retention pond and methods of performing surveys using geophysical methods of ENPEMF and VES.

district, 3 basins in Tsarychansky and 1 in each Mezhivsky and Synelnykivsky districts.

Retention ponds (Fig. 4) are quadratic facilities with the length of sides measuring 50 to 100 m and average depth of 4 to 6 m. They are located in a half-furrow-half-mound, at the same time the projects include anti-seeping cover of polyethylene film and reinforced-concrete slabs. Their main purpose is to act as reservoirs with pump stations of support located near the irrigation complexes for accumulation and retention of projected volumes of water for irrigation.

The peculiarity of the method of conducting field surveys using the ENPEMF method in retention ponds is survey in profile-area variant. The profiles are located on the dams` ridges, covering the bed and territory adjacent to the pond. In spite of insignificant sizes of the objects, compared with the canals, the total area we examined accounted for almost $15 \cdot 10^3$ m^2. Distance between profiles and points of observation on profiles equaled 3 to 5 m. The research was performed in two stages: when filled with water and empty. This allowed us to substantiate, reliably study and determine the regions of increased seeping, zones of formation of fractures and suffusion processes at early stages of development.

Open canals in most cases have trapezium-like shape and run through the furrows or half-furrow-half-mound (Fig. 5).

Technical service includes arrangement of technological berms. Canals, similarly to the ponds, should

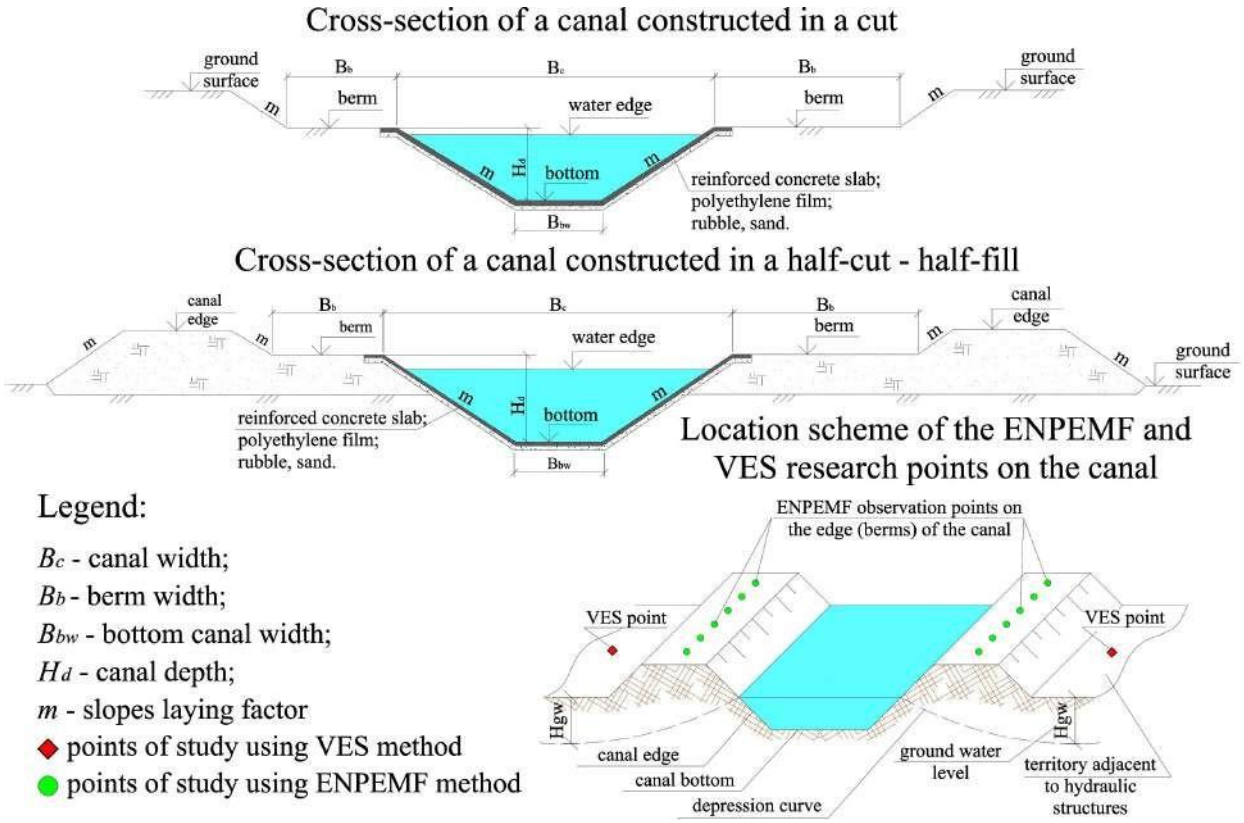


Fig. 5. Constructive scheme of irrigation canal and methods of surveys using geophysical methods of ENPEMF and VES.

have anti-seepage facing in the form of polyethylene film and reinforced-concrete slabs, The main purpose of the canals is transportation and provision of water to remote locations.

Peculiarities of methods of field surveys on main canals depend on the constructive characteristics of the objects. Because the canals are long and have insignificant width, the works were carried out in the profile variant, one profile in each of left and right dams at the distance of 2-3 m from the internal bank. The distance between the monitoring points in the profiles equaled 3 to 5 m. In both cases of surveys, the topographic division of the network was not needed, GPS navigator references were enough.

According to the data of study using ENPEMF method, the objects had damaged areas and zones of increased seepage of water. We should note that this method can not only prove visually recorded zones, but also determine externally unnoticeable areas of seeping deformations on the constructions and early stages of concentration of water seeping from the structures. To determine the level of groundwater and calculate quantitative parameters of water discharge, in the detected zones we made measurements using VES. Generalized results of visual monitoring and surveys using geophysical methods allowed us to sufficiently accurately and quickly obtain data on the technical condition of the facilities and discharges of water from them on large areas of irrigation networks.

Using this method the authors performed a considerable amount of monitoring in different districts of Dnipropetrovsk Oblast (Orlinskaya et al., 2012; Pikarenya et al., 2013)

Results and discussion. The long period of exploitation and absence of required technical monitoring and repair works have led to worsening of the conditions of safe and reliable operation of the facilities. According to the results of visual diagnostic monitoring of the main canals and retention ponds of the irrigation systems, we determined the following types of damage in the constructions (Fig. 6) which are typical for all objects of the ameliorative complex of the country: reinforced-concrete cover slabs were partly ruined, and completely absent at some of the sites; polyethylene anti-seeping film was damaged and required substitution; on the slopes active development of shrub vegetation was seen, which ruins the integrity of the body of the hydrotechnical structure. Such situation was observed in most HTFs. Unsatisfactory technical conditions of the facilities causes significant losses of water from the irrigation systems, decreasing their efficiency coefficients.

Thus, water-transporting and water-regulating elements of the irrigation systems have become potentially ecologically dangerous objects which negatively affect the ecological-ameliorative condition

a b

Fig. 6. Ruined areas of anti-seeping coverage at the current stage of technical exploitation of the structures: a – retention pond; b – main canal

of the neighbouring territories. Just according to the results of visual monitoring alone, the condition of the vast majority of the facilities requires significant impovement in the level of technical and ecological reliability and further safe operation.

The volume and substantiality of the results of our studies are proved by a large number of conducted experimental and practical surveys (Table 1).

cess of actual discharges as over 2.6 times compared with the projected ones (Reclamation systems and structures, 2000).

Therefore, the surveys revealed the total length of damaged areas which according to the total length of the facilities vary from 20% in the retention ponds up to 34% in the canals, indicating the unsatisfactory technical condition of the objects. We determined that

Table 1. Quantitative parameters of executed experimental and practical works

Hydrotechnical facilities*	Number of surveyed objects	Total length of soil dams, m	Number of profiles using ENPEMF	Total length of surveyed profiles, m	Number of points of observations using ENPEMF	Number of points of observations using VES	Length of damaged areas of the constructions, m	Structure of damaged zones to the total length of objects, %
RP 10		3,450	353	61,578	12,908	65	685	19.9
MC	3	56,500	10	74,165	26,474	41	19,316	34.2
Total	13	59,950	363	135,743	39,382	106	20,001	-

Note: RP – retention ponds; MC – main canals

Based on the performed research using the methods of Earth's natural pulse electromagnetic field (ENPEMF) and vertical electric sounding (VES), there are presented the generalized calculations of seepage discharges depending on the length of structures and determined evaporation losses depending on the area of the water table.

Seepage discharges of water from elements of irrigation systems were calculated in the conditions of homogenous soil in the context of seeping flow without pressure. General parameters for 3 main canals and 10 retention ponds of Dnipropetrovsk Oblast were calculated at minimum and maximum levels of water in the structures (Table 2). We should note that on the example of retention ponds, we determined ex-

non-productive losses of water for irrigation may vary from 3.95 M m^3 at minimum levels of water in the structures to over 5 M m^3 at maximum levels. Currently, for the needs of irrigation, around 23 M m^3 of water is withdrawn from various sources. Thus, the volume of irreversible losses from the elements of irrigation systems can reach 17 to 22% of the total. In the current conditions of operation, at average cost of irrigation water equaling about 4 hryvnias per 1 m^3 , oriented loss in the money equivalent can account for ~16 -20 M hrn per season.

The large amounts of seepage losses also affect the level of groundwater in the adjacent territories, leading to waterlogging of the lands, change in the qualitative and quantitative parameters of ecological-

Table 2. Calculation of water losses from the elements of ameliorative systems (generalized indicators)

Hydrotechnical facilities* Per 24 h, q, m^3/24 h		Calculated seeping water losses (taking into account parameters of detected areas of breakdowns and damages in the structures)		
		Per month, q, m^3/month	Per watering season (5 months), q, m^3/season	
RP	min	1,723	51,675	258,375
	max	1,915	57,460	287,300
MC	min	24,616	738,468	3,692,340
	max	31,598	947,936	4,739,680
Total	min	26,338	790,143	3,950,715
	max	33,513	1,005,396	5,026,980

Note: RP – retention pond; MC – main canal; min – calculations at minimum water level; max – calculations at maximum water level in the structure.

ameliorative condition of irrigation sites and chemical composition of groundwater. An additional factor of ecological threat is low quality of irrigation water (Rudakov et all., 2019). We should note the threat of deterioration of the quality of water resources for the needs of irrigation (Fig. 7).

salinization, sodification, alkalinization, toxification of lands, etc.

Fig. 8 presents the dynamics of change in the irrigation areas of Dnipropetrovsk Oblast according to the threat of impact on soils as a result of watering with low-quality water.

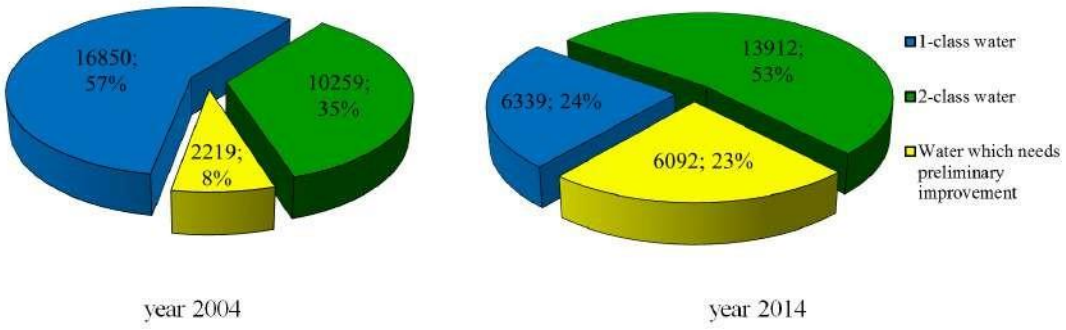


Fig. 7. Deterioration of quality of water for irrigation in relation to irrigated areas (ha; %) in Dnipropetrovsk Oblast in 2004-2014.

The territory of the sites irrigated with water which needs preliminary improvement increased from 2,219 ha in 2004 to 6,092 ha in 2014, i.e. by 2.75 times over 10 years.

The quality of irrigation water directly affects the evolution of soils. Watering with low-quality water leads to dangerous processes, particularly secondary

Analysis of the data given in Fig. 8 suggests significant changes in the irrigated areas according to several types of threat, rapidly deteriorating ecological situation in the irrigated sites and neighbouring territories. Therefore, the dynamics of irrigated areas over ten years (from 2004 to 2014) indicates a 1.4-fold increase in danger of secondary salinization, 2-fold

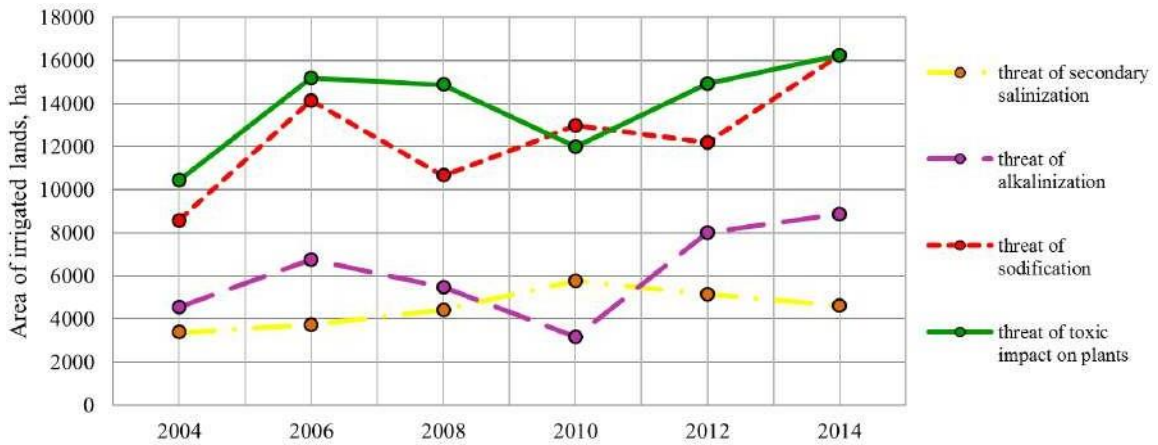


Fig. 8. Dynamics of change in the area of irrigated lands of Dnipropetrovsk Oblast in 2004-2014 according to the threat of impact of soils as a result of low quality of aquatic resources.

increase in the threat of sodification, 1.9-fold increase in danger of alkalinization, and 1.5-fold increase in threat of toxic effect on plants.

An indicatory element of deterioration of the ecological component of managing irrigational land development is the structure of changes in the irrigated areas (Fig. 9). Among the abovementioned elements of hazardous impact, we can clearly see a rapid decrease in the area of fields irrigated with water of normative quality. Such territories decreased by 2.65 times.

Discussion of the results. The presented quantitative parameters of experimentally determined damaged areas of the hydrotechnical facilities indicate significant deterioration in the technical condition of the vast majority of hydrotechnical facilities in Dnipropetrovsk Oblast, which is typical for the ameliorative complex of the country. Long absence of repairs and required technical monitoring, violation of requirements concerning expected loads and effects over the substantiated period of operation of the facilities have led to a collection of a number

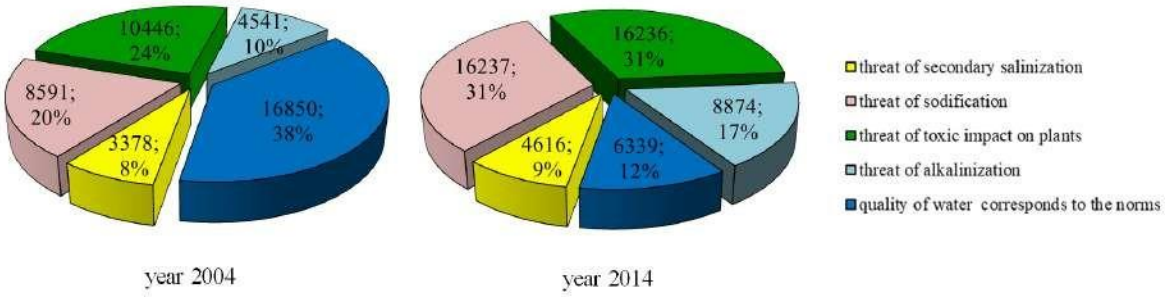


Fig. 9. Structure of change in the area of irrigated lands (ha; %) in Dnipropetrovsk Oblast according to threat of impact on soils as a result of low quality of aquatic resources for the period of 2004-2014.

Water lost from the hydrotechnical facilities is not lost unnoticeably – it elevates the level of groundwater and leads to formation of excessively moistened areas along the canals with plots of marsh-reed vegetation, significantly affecting the ecological balance in the agrolandscapes.

The obtained results of the surveys indicate ecological threat of further exploitation of the retention ponds and main canals not only due to unsatisfactory technical condition, but also due to significant deterioration in the quality of water resources. This underlines the necessity of improving the technical condition of hydrotechnical facilities and setting greater requirements regarding the quality of irrigation water.

In view of the facts mentioned above, a relevant issue is the assessment of risks of waterlogging in the territories adjacent to the canals and ponds. Risk coefficient R determined based on the extent of threat and level of vulnerability to waterlogging is evaluated according to the principle of crossing of these events. On the example of the studied objects it was determined in correspondence to the normative document (Ministry of Housing and Communal Services of Ukraine, 2010) ranging 0.05 to 0.2.

Generalization of the obtained parameters allows us to state the extent of risk, classifying it as low and moderate. At the same time, we should emphasize that decrease in the level of ecological threat as a result of large losses and low quality of water resources has a remote-in-time accumulating effect.

of technical problems, thus categorizing the objects as ecologically dangerous. In order to solve this problem of restoration and further development of ameliorative systems, it is relevant to determine the amounts of work and resources needed to perform repair-restoration works, and also the order of their implementation. First of all it is necessary to determine the most potentially threatening areas using monitoring surveys.

The main directions of implementation of and methodological approaches to improvement of technical and ecological condition of the facilities must be based on the methods of systemic optimization of complex technical-natural systems (Turchenyuk et al., 2017).

The presented list of measures is expedient from the practical perspective, therefore allows providing efficient functioning of HTFs in irrigation systems due to the ecologically-economically based optimization of constructive, technical and technological parameters and indicators of operation of the facilities. An approach to complex mechanism of regulation of the mentioned elements of functioning of HTF of the ameliorative complex is proposed (Fig. 10).

Conclusions

1. The performed historical analysis of existing sources presents the main stages of development of the ameliorative complex in the territory of Dnipropetrovsk Oblast. We determined the significant periods of work of most objects, and also their non-

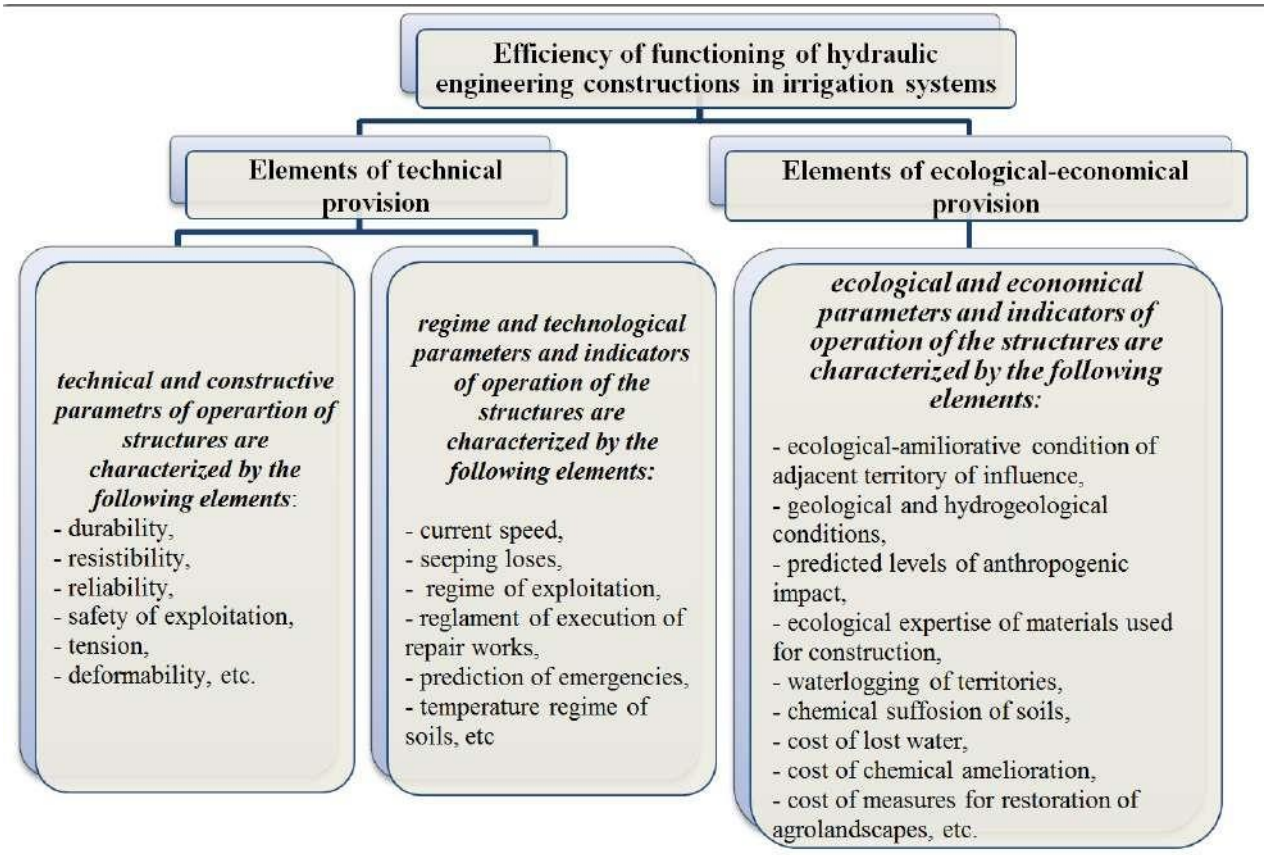


Fig.10. Elements of technical and ecological and economic support of efficiency of functioning of hydraulic engineering constructions on irrigation systems

correspondence to the contemporary requirements of technical and ecological reliability of exploitation.

2. We performed field surveys to determine the current level of technical exploitation of the hydrotechnical facilities. We conducted visual diagnostic monitoring, and also instrumental surveys using a complex of geophysical methods of Earth's natural pulse electromagnetic field (or ENPEMF) and vertical electric sounding (VES). The reliability of the obtained results is proved particularly by the significant amount of survey-methodological work carried out and their practical implementation.

3. We determined that the share of the damaged areas where zones of water seepage and suffusion were found is 20 to 35% depending on the type of construction of the facilities. The main disadvantages of technical condition are ruination of anti-seeping cover of reinforced-concrete slabs and polyethylene film, development of shrub vegetation on slopes and berms of the facilities, formation of areas of seepage deformations.

4. We determined the amounts of seepage losses from the transporting and regulating hydrotechnical facilities. Depending on the level of water they accounted for 3.9 to 5 M m^3, which in the contemporary economic conditions of water provision are equivalent to money losses equaling 16-20 M hryvnias per season.

5. The article shows that further exploitation of the facilities threatens the ecology because of significant worsening of quality of surface water resources. We showed the threat of changes in irrigated areas according to the danger of secondary salinization, sodification, alkalinization and toxicification. The areas of land where irrigation water requires preliminary improvement of qualitative parameters account for around 20 thou ha, which is 76% of the total area of watered land.

6. We calculated the coefficient of ecological risk of waterlogging of territory in the zone of influence of the hydrotechnical facilities, which is mostly classified as low or moderate.

7. We proposed and substantiated the approaches to improvement of the general level of technical exploitation of hydrotechnical facilities. The practical task is implementation of the constituents of technical and ecological-economic provision of efficiency of functioning of the objects, based on the methods of systematic optimization of components of technical-natural complexes.

8. We substantiated the expedience of using contemporary, relevant and low-cost methods and

means of technical diagnostics of the facilities, which would allow not only identification of externally unnoticeable areas of deteriorated condition, but also for them to be identified at the stage of initial development and then repaired. Timely diagnostics and technical evaluation would contribute to the prediction of composition, amounts and order of performance of repair-restoration works at different stages of operation.

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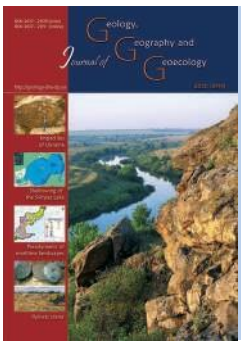

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Analysis of Mountain Relief for the Causes of Snow Avalanches

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Abstract. The descent of avalanches is quite a usual phenomenon for the Ukrainian Carpathians, as well as for the conditions of mountain terrain in general. The Gorgany range of the Carpathian mountains is a typical avalanche-prone territory. Avalanches cause significant damage to forestry and may lead to casualties. Therefore, descent of avalanches has for a long time been a subject of fundamental research in geomorphology, meteorology, topography, photogrammetry and GIS technologies. Using photogrammetric mapping, we analyzed the causes of the descent of one of the largest avalanches in the Ukrainian Carpathians for the past 15 years. The avalanche fell from Poliensky mountain in the Gorgany mountain range in 2006, causing destruction of a great amount of forest. The main causes of avalanches were divided into two groups, the first including more or less stable factors caused by impact of terrain and somewhat less by solar radiation and the second group comprising meteorological factors, such as prolonged snowstorms and snowfall, that is, different fluctuations in weather. The main attention was paid to the first group of factors. For this purpose, a digital terrain model (DTM) of the study area was developed, visualizing the terrain, demonstrating the studied slope of the mountain along which the avalanche slid. According to the digital model, we developed maps of the steepness and exposition of the slope. Also we calculated the coefficient for solar radiation incident on the slope and which depends on the height of the Sun above the horizon and the coordinates of the slope. Using these data, the illuminance map of the Poliensky mountain area was developed. Studies conducted using GIS technologies led to the conclusion that the determining factors that triggered the powerful avalanche from Poliensky mountain were the great steepness and length of the slope, as well as the absence of forest at the top of the mountain, i.e. at the beginning of the avalanche track.

Keywords: avalanche; mountainous terrain; relief; illumination; slope; forest; geoinformation technologies; visualization

Аналіз гірського рельєфу щодо причин виникнення снігової лавини

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Анотація. Виконано аналіз причин сходження однієї з найбільших снігових лавин в Українських Карпатах за останні 15 років, – тієї, що зійшла з гори Полєнський гірського масиву Ґорґани 24 березня 2006 року і призвела до знищення великої кількості лісу. Основні причини сходження снігових лавин розділено на дві групи. До першої віднесено більш-менш стабільні чинники, викликані морфометричними факторами, а саме впливом рельєфу та, дещо меншою мірою, сонячної радіації. До другої групи віднесено чинники, які можуть значною мірою змінюватися з часом. Це метеорологічні фактори, а саме – тривалі заметілі та снігопади, тобто різні коливання погодних умов. Основну увагу приділено першій групі чинників. Для цього створено цифрову модель рельєфу досліджуваної території, що дозволило візуалізувати рельєф, наочно представити досліджуваний схил гори, по якому зійшла лавина. За даними цифрової моделі побудовано карти крутизни та експозиції схилів. Також розраховано коефіцієнт сонячної радіації, яка потрапляє на схил і залежить від висоти Сонця над горизонтом та координат схилу. За цими даними створено карту освітленості району гори Полєнський. Проведені дослідження з використанням ГІС-технологій дозволили зробити висновок, що визначальними чинниками, що призвели до сходження потужної снігової лавини з гори Полєнський, були велика крутизна та довжина схилу, а також відсутність лісу на вершині гори, тобто на початку шляху лавини.

Ключові слова: снігова лавина, гірська територія, рельєф, освітленість, схил, ліс, геоінформаційні технології, візуалізація

Introduction. Analysis of causes of avalanches – such as for example prolonged blizzards and snowfalls, rapid fluctuations of weather conditions and temperature due to radioactive melting of snow, terrain and vegetation of an area, etc – indicates that they could be divided into two groups. The first group comprises factors which are unstable and may change over time, while the second one includes factors which to some extent or other in a particular area could be considered stable. Locations of slides of avalanches or avalanche-prone areas are characterized by stable factors such as relief of the Earth`s surface and to a certain extent the amount of solar radiation incident on the area. These aspects will be analyzed in this article.

Poliensky mountain is located in the Ukrainian Carpathians, within the Gorgany Nature Reserve, and particularly Nadvirniansky district of Ivano-Frankivsk Oblast, south of Chernik village and east of Bystrytsia village. The name of the mountain derives from the word "poliana" (locally "poliena" [Ukr. поляна, полєна – glade – *Translator`s note*]), therefore, perhaps, the mountain would be better called Polienska, and not Poliensky [referring to feminine gender of the word – *T.n.*]. The mountain is located in the north-west part of the Dovbushanka range. Its altitude equals 1,693 m, the northern and eastern slopes are steep and inaccessible. The top and pre-top slopes are not forested, with rocky screes, in some places with krummholz of bog pine (*Pinus mugo*); lower there are located forests composed of softwood tree species, particularly spruces, bog pines, cedar. North-east of the peak Kozlii Gorgan mountain (1,617 m) is located , while south-east of the peake are Vedmezhyk (1,737 m) and Dovbushanka mountains (1,754 m).

High avalanche danger is seen in high mountain areas of the district – Bratkivska and Dovbushanka. In total, within this district, 248 avalanche-prone areas were found, where avalanches occur mostly in the winter-spring period. Avalanches occur every year, most often in snowy years; mainly dry-snow avalanches of fresh snow, or after blizzard, more rarely - wet-snow avalanches (during thaws and melting of snow).

Objective and relevance. The objective of this article was performing analysis of causes of one of the biggest avalanches which occurred in the Ukrainian Carpathians over the last 10-15 years, namely the one which fell from Poliensky mountain on 24th March of 2006, causing destruction of a large part of the forest in the Gorgany Natural Reserve. Along its way the avalanche destroys not only a great amount of productive forest but young trees as well, it sweeps all this material down to the foot of the mountain, altering the terrain. From the philosophical point of view, the surface is both cause and effect of the avalanche.

Fig. 1 and 2 show a satellite image of Poliensky mountain, indicating the avalanche track, and a photograph of the northern slope, showing the aftermath of the avalanche.

Figures 1 and 2 show that the avalanche plummeted from the northern slope of the mountain, causing significant losses of forest which still has not recovered, though 14 years have passed. The total length of the avalanche track is 1,380 m, width – 50 to 110 m. The length of non-forested part of the pathway equaled 437 m. Thus, the area of lost forest accounts for around 6.3 ha. Assuming that the average height of trees is 30 m, and the thickness of the trunk – 25 m, distance between the trees – 3 m, we obtain losses of 8,440 trees or 12,410 m^3 of wood.

Therefore, study of snow-sliding processes and analysis of their causes are quite relevant, because apart from financial losses, large avalanches can lead to human casualties.

Analysis of the literature sources. Because avalanches have been studied over several centuries, this topic is described in a large amount of scientific literature sources (Bellaire et al., 2016; Canadian Avalanche Association, 2002; Hendrikx, Murphy & Onslow, 2014; Tykhanovych & Bilaniuk, 2015; Rudyi & Husar, 2011; Rudyi et al., 2012; Rudyi, 2018). The most recent in-depth studies include analysis of physical properties of snow and the soil beneath it. Particularly, one article indicates priority influence of the terrain and presence of forest, especially hardwood tree species on the mountain slopes (Tykhanovych & Bilaniuk, 2015). The surveys of Japanese scientists were focused on the problems of modeling using satellite technologies of spatial distribution of snow cover in mountainous countries (Asaoka & Kominami, 2012). As for the Ukrainian Carpathians, the creation of a digital model of the terrain of avalanche-prone territories as a tool of mapping using GIS-technologies has been substantiated (Hrytskiv, Laikun, & Babii, 2016).

The latest publications of Canadian researchers include a large amount of references to the literature sources (Bellaire et al., 2016; Canadian Avalanche Association, 2002; Hendrikx, Murphy & Onslow, 2014; Margreth, 2007; McClung & Schaerer, 1993; Pistocchi, 2002). Particularly, they note that in studying the causes of avalanches one should take into account determining territorial conditions. One might add that this should be also taken into consideration while choosing tourist itineraries (Kolotukha, 2008).

The object of the research presented in this article is the extremely destructive avalanche which

Fig. 1. Poliensky Mountain (from open internet source)

descended from Poliensky mountain in the Ukrainian Carpathians on 24th of March 2006, and the subject is the terrain of the territory of its occurrence.

Materials and methods of study and results. To analyze the causes of avalanches from Poliensky mountain, we used the methods of geoinformational modeling. Experimental researches were performed using the materials (digital terrain models, DTR) at the Scientific-Research Institute of Geodesy and Cartography using SURFAR software pack on the basis of photo-material collected by the authors (Rudyi & Husar, 2012). The size of the territory the DTR was created for accounts for 15.2 X 14.1 km or 21.5 thou ha. Distance between the nodes of the grid of the digital model was 15 m. Fig. 3 shows a map of the research area. Fig. 4 provides a more detailed image of Poliensky mountain and the slope where the avalanche occurred. The size of the digital model of Poliensky mountain equals 3.2 X 4.3 km or 1.4 thou ha. Distance between the nodes of the grid of the digital model equals 4 m.

Fig. 3 shows that the terrain of the studied area of the Gorgan territory is complex, deeply divided,

Fig. 2. Northern slope of Poliensky Mountain (Rudyi & Husar, 2012)

making it especially avalanche-prone. In many places, avalanches reach the bottom of the gorges, thus blocking the mountain rivers and forest roads.

Methods of digital modeling visualized the terrain of the area, demonstrating the surveyed slope of the mountain along the track of the avalanche , allowing us to analyze its morphometric factors, particularly steepness, length and exposition of the slope. For this purpose, according to the data of the digital model of the terrain, we developed maps of exposition and steepness of the slopes, given in Fig. 5 and 7.

This map indicates the image of orientation of the slopes of Poliensky mountain in relation to the cardinal directions, blue indicates the northern slopes, red – southern, green – western, yellow – eastern.

Regarding exposition, southern slopes are considered to be more prone to avalanche-formation than the northern one, western and eastern being average in this respect. It is explained by the fact that the southern slopes are better heated, and the snow melts there more intensely (Rudyi et al., 2011). In our case this factor is not the determining one, because the avalanche descended along the northern slope. Illuminance of the slopes is another factor leading to avalanche. The current of solar radiation onto the slope S_C depends on the height h and azimuth of the sun A, inclination angle v and azimuth of slope α:

$$E_C = E_O \cdot [\cos h \cdot \sin v \cdot \cos(A' - \alpha) + \sin h \cdot \cos v] = E_O K_S$$

where E_O – current of direct solar radiation onto the surface which is perpendicular to the sunrays of the area of 1 m^2 per 1 sec:

$$E_O = 1.36 \cdot 10^3 \text{W/m}^2 \cdot \text{sec}.$$

The coefficient *Ks*, which is the cosine of the angle between the direction of the Sun and the normal

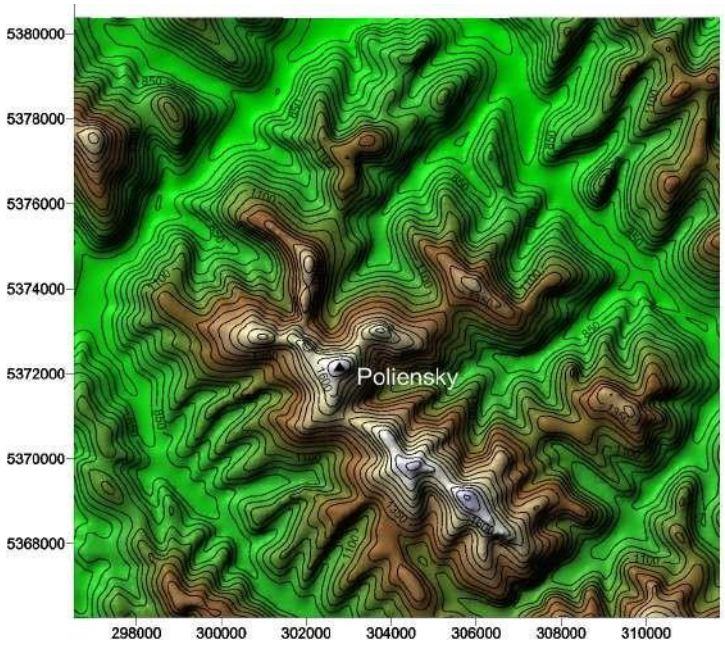

Fig. 3. Digital model of the studied area

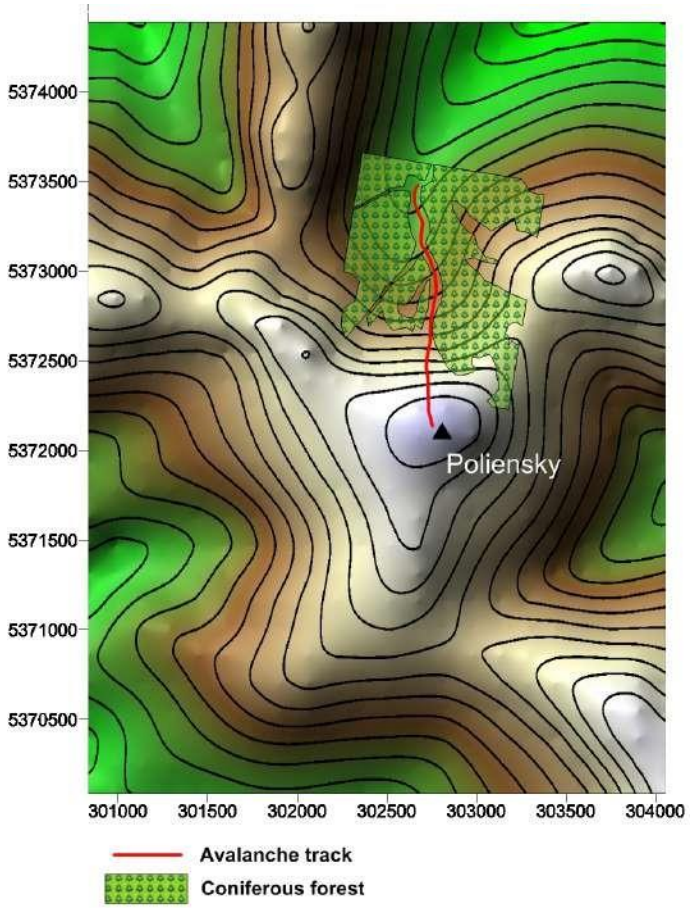

Fig. 4. Digital model of the slope where the avalanche struck

to the earth's surface, was calculated and a map of the illumination of the Polensky mountain area according to these data was created.

We calculated K_S coefficient which is the cosine between the direction towards the sun and the normal to the earth surface = normal surface of the Earth`s surface, and according to these data, we developed the map of illuminance of Poliensky mountain given in Fig. 6.

According to the content of Fig. 6 which shows the division of the territory of Poliensky mountain according to the angles between the direction towards

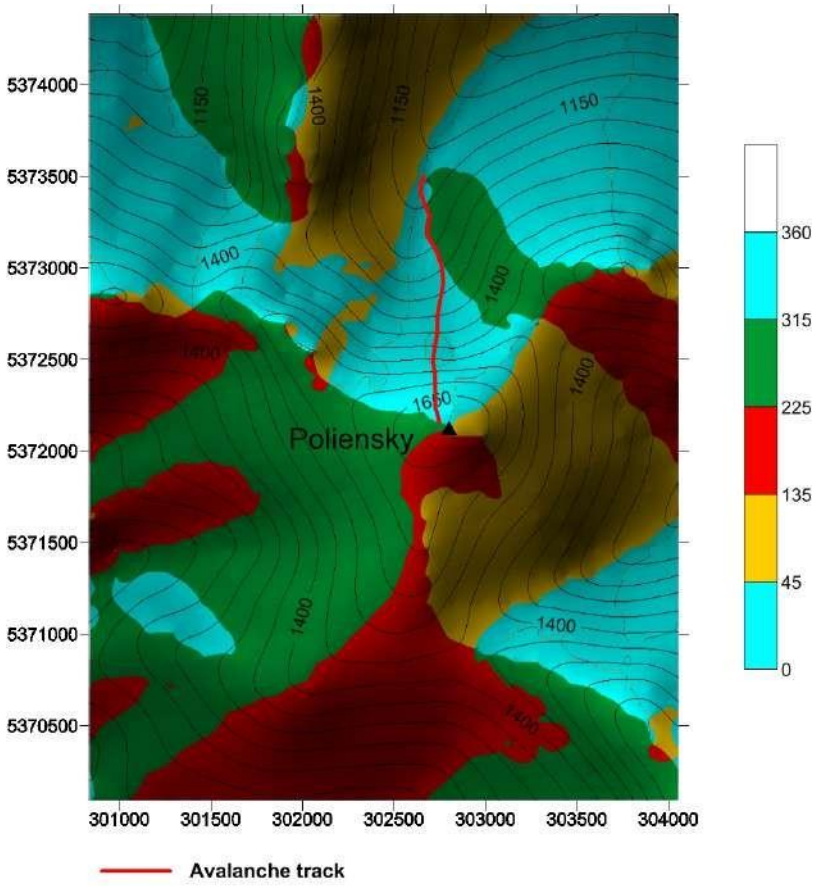

Fig. 5. Map of the exposition of the slope

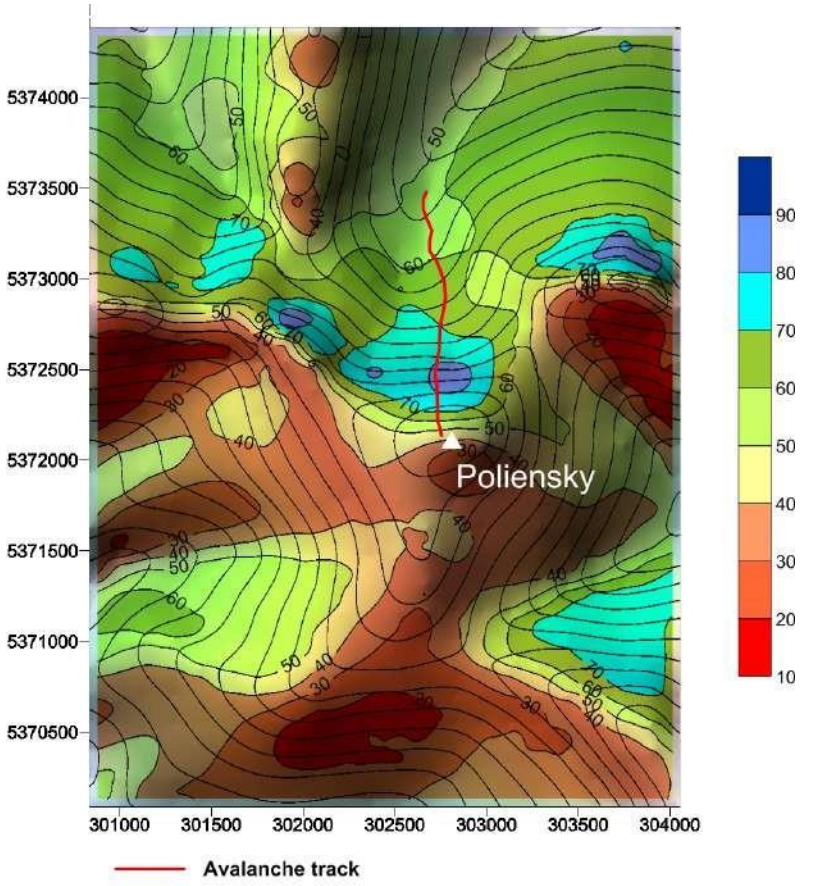

Fig. 6. Map of the illuminance of Poliensky mountain (Levchenko & Shynkarenko, 2003)

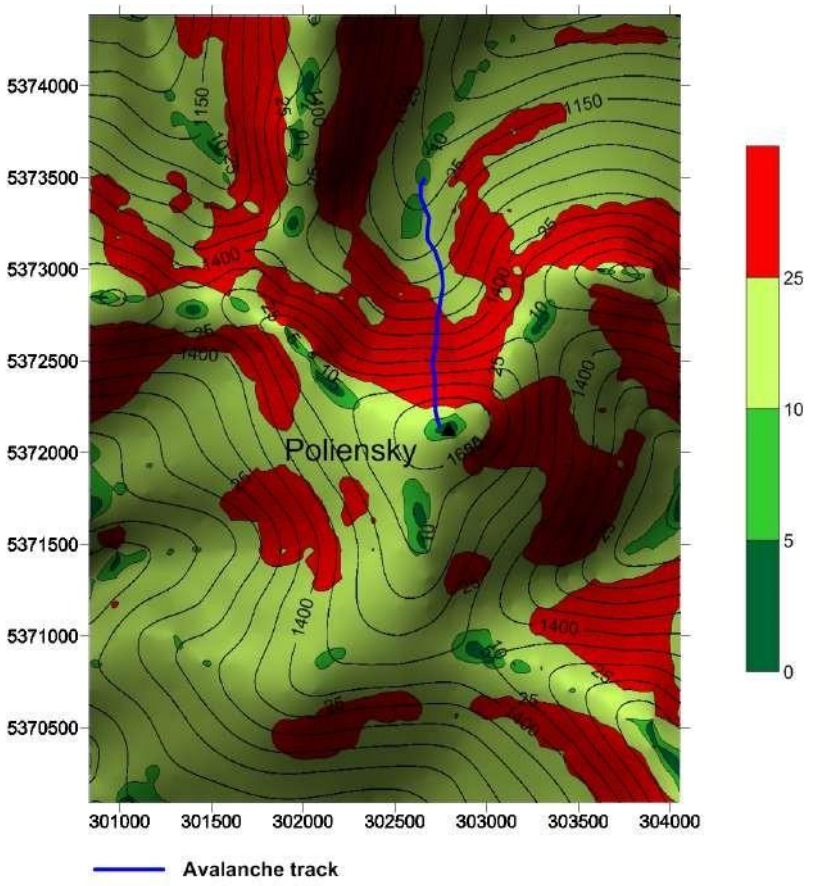

Fig. 7. Map of the steepness of the slope

the sun and the normal towards the earth surface (the lesser this angle, the larger amount of heat is incident on the slope), the avalanche fell along moderately illuminated slope. Thus, the illuminance factor was also not the determining one in this case.

Therefore, the determining factor in this case, apart from meteorological conditions of course, is the terrain of the area. According to the developed map of steepness, the slope on which the avalanche descended is characterized by great angle of steepness. If one does not take into account the height of the mountain with insignificant slope angle of up to 10°, then the first half of the avalanche track runs along the slope with steepness angle of over 25°. The length of the avalanche`s pathway is 1,380 m.

Great length and inclination angles of slopes contribute to occurrences of avalanches in forest cuttings and even in forests. Particularly those factors were determining during the formation of the avalanche on the northern slope of Poliensky mountain. Such conditions of terrain underlie the occurrence of an avalanche of great kinetic energy and development of a wind shock wave which can cause destruction, and even destroy areas of forest on opposite slopes.

Conclusions and perspectives for further studies. The studies performed using GIS-technologies allowed us to state that the determining causes of the avalanche from Poliensky mountain were great steepness and length of the slope and also absence of forest on the mountain peak, i.e. at the starting point of the track of the avalanche (437 m). At the same time, occurrence of the avalanche on the northern slope with low illuminance makes it non-typical, because as we know intense heating particularly of southern slopes leads to development of avalanche processes.

Obviously, apart from morphometric factors, the formation of the studied avalanche and its fall in the indicated place was to a large extent affected by the meteorological factor, particularly great amount of snow, and perhaps formation of a “visor” or “cornice” on the peak and its further dislodging in particular weather conditions, leading to an avalanche, while absence of forest composed of hardwood trees meant there was no obstruction to the sliding. Detailed study of the role of meteorological factors in development of avalanches in the Ukrainian Carpathians in general and the one that descended from Poliensky mountain in 2006 in particular can be one of directions of further studies of causes of development of avalanches.

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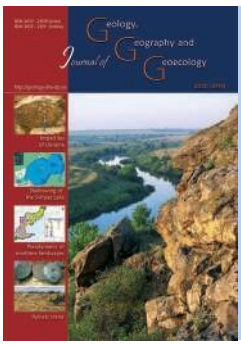

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Areal communities' centres of Poltava Region as social-economic growth poles

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Abstract. The article embraces the thorough analysis of the social-economic space of Poltava Region via administrative-areal reform as well as united areal communities' formation. Given research has its base in the methodology of spatial analysis of areal systems with different levels of their organization. As a result, the very essence of social-economic growth poles' forming process was revealed in succession. The fact this growth poles' formation on depressive territories tends to be the ultimate way to improve their social and economic status has been logically ascertained. The typification of Poltava Region united areal communities' centres as social-economic growth poles was held according to such criteria as their formation and impact extension over the surrounding territory. Actually, the forming peculiarities and the further development of growth poles on the regional level have an urgent necessity under active administrative-areal reform. Therefore, the prerequisites and the forming factors of Poltava Region growth poles were clearly defined. As a result, all the groups' types of regional social-economic centres, which are already formed social-economic development poles (Poltava, Kremenchuh), development poles under formation (Horishni Plavni, Myrhorod, Lubny, and Hadiach), centres with some prerequisites to transform into growth poles (Karlivka, Pyriatyn, Lokhvytsa, Zinkiv, Hlobyne, and Kobeliaky), and centres with insufficient capacity to transform into growth poles (Velyka Bahachka, Kozelshchyna, Mashivka, Novi Sanzhary, Opishnia, Reshetylivka, Semenivka, Chornukhy, and Shyshaky), have been classified correctly. Those centres that have low formation level, being unable to transform into growth pole (Bilotserkivka, Butenky, Velyki Sorochyntsi, Drabynivka, Zavorsklo, Zasullia, Klepachi, Kolomatske, Krasna Luka, Lanna, Mala Pereshchepyna, Machukhy, Mykhailivka, Nedoharky, Nekhvoroshcha, Novoavramivka, Novoznamianka, Obolon, Omelnyk, Petrivka-Romenska, Pishchane, Pokrovska Bahachka, Pryshyb, Rokyta, Rudenkivka, Sencha, Serhiivka, Skorokhodove, Tereshky, Shcherbani), consolidate into the specific pattern. The results of the research aim to provide the primary, administrative, and social-economic UAC centers' functions. As a matter of fact, the fundamental prerequisite of the Poltava Region' area sustainable social-economic development can be efficiently contributed by already formed poles. They are, in fact, able to maintain the conservation of regional ecosystems, the areas' innovative development achievements, the overcome of poverty, the preservation of national values and traditions, etc. Only the transformation of the described centers or acquiring them the nuclei traits of social-economic development poles should ensure the balanced areal development of the region.

Key words: Poltava Region, administrative-areal order, UAC (united areal community), centre, social-economic development

Центри територіальних громад Полтавської області як полюси соціально-економічного зростання

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Анотація. Стаття включає комплексний аналіз соціально-економічного простору Полтавської області крізь призму адміністративно-територіальної реформи та формування об'єднаних територіальних громад. Робота базується на методології просторового аналізу територіальних систем різного рівня організації. Методика дослідження передбачала послідовне виконання наступних операцій: визначення ролі і місця центрів ОТГ в економіці, територіальній структурі господарства і розселенні населення; дослідження чинників, які визначають процеси розвитку центрів ОТГ; аналіз взаємовпливів розвитку господарства, його спеціалізації і центрів ОТГ; визначення сучасного стану і тенденції розвитку центрів ОТГ сільських районів; установлення ролі центрів ОТГ у формуванні господарських систем; обґрунтування моделі класифікації центрів ОТГ як полюсів зростання; проектування напрямів розвитку полюсів зростання на базі центрів ОТГ. Розкрито сутність процесу формування полюсів соціально-економічного зростання. Установлено, що формування полюсів зростання на депресивних територіях є єдиним шляхом покращення їх соціально-економічного стану. Здійснено типізацію центрів об'єднаних територіальних громад Полтавської області як полюсів соціально-економічного зростання за критеріями сформованості та

масштабами впливу на навколишню територію. Підтверджено, що на тлі проведення адміністративно-територіальної реформи особливості формування й подальшого розвитку полюсів зростання на регіональному ріні мають виключну актуальність. Визначено передумови і умови формування полюсів зростання у Полтавській області. Результатом дослідження є виділення типів груп регіональних соціально-економічних центрів: сформовані полюси соціально-економічного розвитку; полюси розвитку, що формуються; центри, що мають передумови для трансформації у полюси зростання; центри, з недостатніми можливостями для трансформації у полюси зростання. В окрему групу виділено центри з найнижчим рівнем сформованості, що фактично не мають можливості для трансформації у полюси зростання. Результати дослідження спрямовані на забезпечення не лише ключової адміністративної, а й соціально-економічної функції центрів територіальних громад. Доведено, що базовою передумовою сталого соціально-економічного розвитку території Полтавської області є сформовані полюси, що здатні забезпечити збереження регіональних екосистем, досягнення інноваційного розвитку територій, подолання бідності, збереження національних цінностей і традицій тощо. Трансформування виділених центрів чи набуття ними головних ознак полюсів соціально-економічного розвитку зможуть забезпечити збалансований територіальний розвиток області.

Ключові слова: Полтавська область, адміністративно-територіальний устрій, об'єднана територіальна громада, центри, соціально-економічний розвиток

Introduction. Up-to-date tendencies of Poltava Region social and economic space uplift as well as the decline of branches, has been dominant in economic activity specialization, the territorial disproportion on the development of towns and rural areas, the depopulation likewise the decrease of population's life conditions and quality are those crucial traits, which nowadays form the background of national regional policy. The administrative-areal order reform bares the status of the key one at the areal development. It has been set up in conjunction with so-called decentralization reform, resulting in united areal communities' (UAC – hereafter) formation. Nowadays the mentioned above process has its active prolongation in Poltava Region; it provides the further association of local councils for rational usage of local budget and successive increase of the population's life quality likewise the sustainable growth of the area.

In up-to-date terms, the necessity of a new country's regionalisation stems from Ukraine's strategic priority for EU integration, preceding by the administrative-areal order formation, as per NUTS (Nomenclature of Territorial Units for Statistics) requirements. The conceptual framework of the given article addresses Ukraine's official papers, including the Presidential Decree "On the Concept of a Regional Public Policy" (2001), the Laws of Ukraine "On the Principles of a Regional Public Policy" (2015) and "On a Voluntary Unification of Areal Communities" (version of 2019). It also takes into account the Cabinet of Ministers Resolutions "On the Amendment of Methods of Competent Areal Communities' Formation" (2020) and the Methodical Recommendations on the criteria of sub-regional (district) administrative-areal units' formation (2019). The elaboration of principal theses of areal development, based on the theory of growth poles, was founded on acquisitions of François Perroux, Jose Ramon Lasuen, Immanuel Wallerstein, George Friedman, and Stig Torsten Erik Hägerstrand.

The core of this theory defines the role of dominant branches of economy in a certain locality, referring to their potential to cause economic growth in the whole influence area. Diverse aspects of the areal development occurred in the research focus of many Ukrainian economic geographers, such as Y. Pitiurenko, I. Horlenko, S. Ishchuk, O. Shablii, A. Dotsenko, A. Stepanenko, O. Topchiyev, Y. Oliinyk, M. Baranovskyy, V. Yavorska, etc. Significant scientific studies have been held in the field of public administration, particularly in substantiation of the principles of areal development management, areal development forecasting (K. Mezentsev, 2005), geoplanning (Malchykova, 2014), geospatial research and spatial planning practice (L. Rudenko, S. Lisovskyi, Y. Maruniak, 2016). The areal development theories' key principles, having been successfully adapted to market conditions, represent the results on increasing competitiveness, production specialization and balanced areal development as well as ascertain market infrastructure creation, areal industries organization and reveal the growth poles in the context of spatial inequality and polarization. The amount of these issues was logically displayed in disquisitions by S. Zapotoczkij (2012), K. Mezentsev, N. Mezentseva, H. Pidhrushnyy (2014), I. Pilipenko (2015), O. Topchiyev, D. Malchykova, V. Yavorska (2015), etc. The problem also got its deep consideration during the seminar, held at the Institute of Geography of The National Academy of Sciences of Ukraine (2013). It is true fact, that the theory of economic space gets a wide prevalence in Ukrainian social geography; peculiar attention is being paid to the problem of economic space, focused upon the district-forming nuclei or specific areas. To solve the crucial problems of the Poltava Region areal development, to decrease disproportions in social and economic growth of its area or certain localities, to optimize the industry branch structure likewise the population resettlement the thorough scientific search has to be directed into the

exposure, incitement and support of the new social and economic growth poles. The majority of Poltava Region rural areas became depressive territories during the Independence period; they represent ineffective branch structure of the economy with the leading role and share of raw-oriented industries, lack of agricultural competitiveness, cattle-breeding in particular, unemployment, increase of migration, and depopulation of inhabitants. General geodemographic situation in Poltava Region reveals the ultimate risks for the future development of this area, mainly due to the gradual decrease of natural population growth, unbalanced sexual and aged structure of the population, which is a deterrent in the reproduction mode of the latter, causing the fast decline of inhabitants in total. The administrative-areal order of Poltava Region (districts, various by area, configuration, and population, long distances to administrative centres, etc.) determines different efficiency of these centres in their functions' execution. The mentioned above problems are among essential obstacles in the further effective development of the local area; they actually minimize state reforms' implementation efficiency in stimulating areas development and do not contribute the effective fulfilment of Poltava Region social-economic potential.

The effective system of growth poles should play an exclusive role in the problems' solution. As development indicators, these centres have to become drivers of long-awaited changes of Poltava Region's social-economic space according to the district-forming effect and to spread the development impulses over surrounding areas. Growth poles' forming process also should lead to the improvement of the region's areal structure, stimulating dominant branches of economy. Thus, the necessity to make a perspective social-economic development poles' model got its particular relevance in terms of Poltava Region development strategic planning. Potentially it will embrace scientifically sound analysis of polarization and depressiveness of the social-economic space of the region likewise will provide typification of the UAC centres as social-economic development poles. It also will ascertain and predict their role in the process of Poltava Region areal society structure improvement. The utmost achievement of the given above aspects depends on thorough analysis and modelling of areal processes of Poltava Region economic complex development, and all the branches of its specialization, especially considering those connected via production ties with agriculture. Similarly, it depends on the scrupulous analysis and modelling of processes of transport infrastructure and social sphere development, population employment ensuring, and areal optimizing of inhabitants' life quality indicators set. Actually, fundamental implementation of this approach into the areal prognostication practice and social-economic development planning can provide UAC centres with the status of growth poles not only by towns but also by localities in some rural areas as basic components of Poltava Region social-economic development. The persistent improvement of infrastructure, stimulation of the manufacturing industry, agriculture and social sphere branches' development are the very incitements to transform these centres into important cells of social-economic development of surrounding territories and the region in total.

The aim of the given research is to provide the comprehensive analysis of the formation level of Poltava Region UAC centres as social-economic growth poles and to justify suggestions of its further development. During the acquisition the fact the growth poles' forming, on the one hand, reveals to be the objective process of social-economic development and simultaneously the means of achieving territorial disproportions in the population life level and quality was put into consideration. On the other hand, the growth poles' forming could also be a result of purposeful implementation of state regional policy or investment projects. The essence of the research lies in finding out the processes of forming (re-forming) and functioning of areal structures at the grassroots level in the line of regional policy implementation to improve the level and quality of population's life.

The research methodology of UAC centres as social-economic growth poles has its basis on fundamental methodological principles of the social geography. Given study is grounded on doctrine of complex- and system-formation, manifested in areal self-organisation of all the spheres of human activity, in emergence and expansion of social-economic ties and relations, in the natural environment transformation, and areal communities' consolidation. Areal self-organisation of the society has traits of differentiation and discreteness, which become apparent in a form of administrative-areal order and system of regions of various taxonomic rank. Regional units of any hierarchical level are areal systems, actually realized in social-geographic space and historical timeline. During the process of society spatial self-organisation improvement the grassroots level areas' centres' are formed, making the possibility to combine governance and market self-regulation.

The detection of functions and role of UAC centres was held on the base of theoretical theses of the

"centre – periphery" modelled by George Friedman. Reducing functioning efficiency of the economic complex, the decline of its competitiveness as well as imperfect regional development policy and demogeographic situation exacerbation cause the loss of traditional development resource base of the majority of Poltava Region areas. In fact, methodological basis of UAC centres research has its roots in scientific works by Johann Heinrich von Thünen, who conducted the model of spatial development of economic systems around centres of production consumption.

Persuasive usage of these approaches simultaneously to analysis of UAC centres comprehensive state of Poltava Region, located in rural areas, logically ascertained the evidence of sustainable interconnection trends between UAC centres, being mainly small towns or urban settlements, and social-economic state of surrounding territory. At the same time, in terms of market transformations, connected primarily to the impact of information technologies and scientific-technological progress on branch structure of economy, this process significantly complicated and gained the new meaning. Therefore, the pre-dominant prerequisites of growth poles' effective formation are the objective analysis of branches of UAC economy specialization, identification of their raw materials sources, forecasting and modelling conditions, favourable for mutual UAC centres and surrounding territory development. Those poles' economic activation can be powerfully provided by innovative development of the economy, competitiveness increase of production, and involvement of specialized industries into regional, interregional, and globe networks.

The research methodology of identifying social-economic growth poles' level of forming on the base of UAC centres covers such essential aspects as:

1) place and role of UAC centres in a regional system of population resettlement, branch and areal structure of economy;

2) impact of social-geographical processes (natural, ecological, historical-geographical, demographical, ethnical, religious, political, economic, etc.) on the development of UAC centres;

3) mutual influence of the development of economy, its specialization and UAC centres;

4) comprehensive state and development trends of UAC centres (geodemographic characteristics, population employment structure, migration processes, economy specialization, development state of social sphere);

5) UAC centres competitive advantages in the process of regional and interregional economic systems' networks forming;

6) classification of UAC centres as social-economic growth poles with a mandatory analysis of their inertial impact on UAC area;

7) forecasting, modelling, and programming of development of UAC centres as growth poles in terms of depressive territories overcoming.

Concurrent to justifying the possibilities of UAC centres social-economic development likewise forming the growth poles on their base the previous in-depth analysis revealed the specificity of areas development alongside with centres' functions in regional resettlement systems forming and development, and changes' trends in geodemographic sphere. The core issue of the represented research lies in the defining the role and place of the UAC and its centre in the areal structure of production and population resettlement, determining their natural-resource, geodemographic, transport-geographical, and economic-geographical position. The final stage of the research embraces the entire analysis of the inner factors of the further development of UAC centres as well as their potential and possibilities to establish economic and social connections with neighbouring areas, to widen the branch structure and to diversify the economy, to elaborate tour-recreational activity.

Thus, the base of the Poltava Region UAC centres, mainly its depressive rural areas, research methodology comprises its intensive study as growth poles. Among the most significant mandatory preconditions, one can name the objective classification of UAC centres after their abilities and substantiation of the most appropriate development scenario variants via UAC area social-economic increase. To do so one should enlist various criteria of centres' classification, especially rates of formation of innovative enterprises of multiple economy specialization branches, terms of their efficiency and production quality increase, integration of higher level of organization into economic systems, achievement of social effect, job positions creation, etc. As a result, the research efficiency and effectiveness of Poltava Region UAC centres as social-economic growth poles is exclusively determined by trends and rates of their impact on the complex development of the community area in general.

Results and discussion. Social-economic growth poles are represented by areal complexes, affiliated by diverse industrial and infrastructural interrelations. Due to their specific state and predicted rates of development, possibilities of usage of areal labour division advantages as well as development rates of specialized branches of economy, growth poles can be divided on real-existing and potentially-predictable ones. These poles as spatial increase nuclei objectively

exemplify higher development rates compared to the area of attraction. Inertial impacts of the formed poles, however, regularly lead to social and economic lifting of the UAC in general. These poles have to represent certain kinds of economic activity, material (historical-cultural, sacred objects) and non-material (area brand, active-participating population) assets, able to produce the increase effects. Their stimulating impact on the social-economic growth of surrounding territories marks the crucial trait of these poles' development.

Modern Poltava Region is an administrative-areal unit of Ukraine the centre of which is Poltava city; it incorporates 25 districts, 15 cities (6 of them are of regional importance, they are Poltava, Kremenchuh, Horishni Plavni, Lubny, Myrhorod, and Hadiach), 21 towns, and 1805 villages. City, town and village councils unite certain number of localities around, they possess common infrastructure and support economic and social interrelations. Each district embodies an average amount of 69 – 70 villages, consolidated into 18 –19 village councils. The average districts' area of Poltava Region makes 1150 km^2. Regional decentralization reform manifested the reformation of 174 local councils by creating (up to January 01, 2019) 45 UACs (6 city UACs, 10 town UACs, and 29 village UACs, in particular). They joint about 34.6 % of local councils of the region, it corresponds to 30.2 % of the region area, and unites 22.5 % of the region population. Up from the beginning of 2019 Poltava Region experienced creation of 8 more communities (Horishni Plavni, Novoselivka, Novoorzhytske, Hoholeve, Romodan, Petrivka, Zinkiv, and Velyki Budyshcha). As of October, 01, 2019 Poltava Region reveals 53 UACs, having consolidated 193 local councils (which makes 38.4% of their total amount), general UACs area makes 9.700 m^2 (it is 33.9 % of the region area), the UACs population counts 0.411 million people (29.3 % of the region inhabitants). It is worthy to mention, that one of the vivid drawbacks in the UACs forming process is the creation of 35 communities, incorporating less than 5000 people.

During 2018, Sencha UAC of Lokhvytsa district ascertained the maximum level (23733.7 UAH per capita) of tax revenues, while Zavorsklo UAC of Poltava district has shown the minimum level (2315.9 UAH per capita) of the earnings. As for September, 01, 2019, the general volume of all the 45 UACs' budgets formed the sum of 2100.8 million UAH, that is 21.0 % (or 364.5 million UAH) more compared to the corresponding period of 2018. Own receipts (without transfers) of UACs has risen by 26.6 % (or 298.6 million UAH); it was 1419.6 million UAH as for September, 01, 2019, and 1121.0 million UAH as for September, 01, 2018. The full monitoring of UACs' income dynamics in 2016 – 2018 unequivocally certifies their increase. In 2016 at 12 UACs such income (including transfers) has grown by 4 times compared to 2015; in 2017 at 18 UACs the income has increased by 1.6 times compared to 2016, and in 2018 at 39 UACs the income grew by 1.6 times compared to 2017. Actually, the income of certain communities rose by from 2 to 8 times. In fact, in 2018 Semenivka UAC had the income (including transfers) increased by 74.7 % compared to 2017, Pyriatyn UAC had the sum grown by 49.5 %; Machukhy UAC, Drabynivka UAC, Rokyta UAC, Velyka Bahachka UAC, and Nekhvoroshcha UAC disposed the amount risen by from 4 to 5 times. The rest of the newly conglomerated communities revealed the revenues increase by from 2 to 3 times during the very first year of national budget decentralization.

Thus, in terms of financial capacity Poltava Region UACs occupy the leading position in all-Ukrainian terrain for the first half of the year 2019. Taking into account UACs with total amount of inhabitants forged from 10 000 to 15 000 people one should range them as follows: Hlobyne UAC – the 5th position, Shyshaky UAC – the 7th position, Shcherbani UAC – the 8th position, Lokhvytsa UAC – the 11th position, Hrebinka UAC – the 14th position. The group of UACs cooperating from 5000 to 10000 people represent their rank as those: Opishnia UAC – the 14th position, Mykhailivka UAC – the 16th position, and Mashivka UAC – the 20th position. Having consolidated less than 5000 of persons, UACs of Poltava Region make their rank as follows: Drabynivka UAC – the 3rd position, Sencha UAC – the 5th position, Krasna Luka UAC – the 8th position, Kolomatske UAC – the 13th position, Lanna UAC – the 15th position. Hadiach UAC held the 18th position among the cities of regional importance (Shevchuk, 2019).

Nowadays in terms of the state management crisis as well as decentralization process the Region urgently needs qualitative and quantitative administrative-areal order reformation, realized in UACs creation. Comprehensive Poltava Region AAO order reforming tends to be an important direction in state governing system improvement at the grassroots level, in upgrading the population living standards, rational usage of natural resources, and sustainable development of the region. Therefore, the AAO order reformation is rather complicated and long-termed process, the successful result of which depends on the thorough study and evaluation of diverse factors and indicators, necessary to UACs or new districts and regions bound-

Table 1. Parameters of Poltava Region UACs as of January, 01, 2019.

№	District	UAC	Population amount (according to State Statistics Service of Ukraine as for January 01, 2019)	Community area, km² (according to State Geocadastre)
1	Velyka Bahachka	Bilotserkivka	3601	200.693
2		Velyka Bahachka	10175	332.633
3		Rokyta	1901	111.839
4	Hadiach	Hadiach	24622	72.484
5		Krasna Luka	3739	215.244
6		Petrivka-Romenska	4368	210.065
7		Serhiivka	2827	167.618
8	Hlobyne	Hlobyne	14503	405.196
9	Hrebinka	Hrebinka	12388	78.348
10	Zinkiv	Opishnia	6238	131.438
11	Karlivka	Lanna	3786	96.765
12	Kobeliaky	Butenky	3649	143.855
13	Kozelshchyna	Kozelshchyna	10404	491.541
14		Nova Haleshchyna	3508	59.225
15	Kremenchuh	Nedoharky	3520	84.774
16		Novoznamianka	4464	82.690
17		Omelnyk	5019	224.821
18		Pishchane	6453	78.028
19		Pryshyb	1957	91.910
20	Lokhvytsa	Lokhvytsa	12410	81.672
21		Sencha	2954	125.068
22	Lubny	Zasullia	16377	604.300
23	Mashivka	Mashivka	7490	136.457
24		Mykhailivka	6009	444.333
25	Myrhorod	Velyki Sorochyntsi	3603	130.756
26	Novi Sanzhary	Drabynivka	4265	245.778
27		Nekhvoroshcha	5164	287.462
28		Novi Sanzhary	8896	32.165
29		Mala Pereshchepyna	4048	238.088
30		Rudenkivka	3843	103.552
31	Pyriatyn	Pyriatyn	16802	97.620
32	Poltava	Zavorsklo	3316	114.130
33		Kolomatske	2279	90.201
34		Machukhy	7959	247.083
35		Tereshky	8742	86.873
36		Shcherbani	13113	98.773
37	Reshetylivka	Reshetylivka	11061	174.260
38	Semenivka	Obolon	2528	137.366
39		Semenivka	10777	271.998
40	Khorol	Klepachi	2665	126.282
41		Novoavramivka	2632	137.201
42		Pokrovska Bahachka	2501	121.249
43	Chornukhy	Chornukhy	9142	512.396
44	Chutove	Skorokhodove	5245	135.636
45	Shyshaky	Shyshaky	14583	611.534
	TOTAL	-	**315526**	**8671.400**

aries' prosperous creation. Above all, Poltava Region growth poles' ways of developing are favourable transport-geographical location, availability of highly skilled labour resources, the sufficient level of market infrastructure objects' level, business climate agreeable for small business development, and investment attractiveness. The main goal of the reformation process is to consolidate capable UACs with much higher social-economic potential is to intensify their budgetary capacity and functional independence.

The perspective plan of Poltava Region communities' formation envisaged the unification of more than 70 areal entities, providing qualitatively new service level in such spheres as housing and utility services, education, health care, social protection, and culture.

All the UACs' modelling criteria, in fact, have its deep base on the fundamental theses of social-geographic zoning, justifying the new model on the area historical-geographical forming peculiarities; area natural-geographical integrity and continuity; attraction to the forming nucleus as centre of all the services. They also include complex-proportional development of UAC as a separate areal system based on the previously formed infrastructural interrelations, on the principles of rational nature use, balanced areas development, and perspectives of their growth.

The regionally-concretized vectors or landmarks of development of territories of Poltava Region include: an intense growth of specific branches of economy specialization; restoration of agricultural and transport engineering; production of equipment for food and light industry; expansion of grain, sugar beet and livestock specialized complexes. The landmarks of areal development of the region likewise include widening the region positions on the national and globe food markets, extension of scientific-technical level of metallurgical complex and chemical industry, enlargement of tourism and recreation potential.

In fact, the dynamic growth poles' formation of Poltava Region needs the implementation of diverse by scope and spheres approaches and types of innovations. Rather fast growth of growth poles', mainly in depressive districts of Poltava Region, is possible, first and foremost, due to localities, specializing in traditional branches of manufacturing industry. Such industries have, as a rule, rather formed ways of the development and rather saved integral production infrastructure. Another indicative condition of the further extension of these localities is scientific and innovative modernization of agricultural branches, focused on producing raw materials for the food and light industries. On the one hand, they provide rapid growth in agricultural production volumes and rates as well as solving a number of rural depressive areas' social problems. On the other hand, these branches can settle the problem of supplying the manufacture industry traditional branches with raw materials. As a result of the restoration of traditional economy branches and the competitiveness of their production in regional and national markets, the implementation of modern innovative technologies in production and social infrastructure, the areas are to overcome depressiveness and get regional development stimulated.

The population amount dynamics of the region is marked as another noteworthy indicator, which determines the dynamics of the population life conditions and quality, therefore, the growth of population amount and life quality shows the positive development dynamics of UAC's centre. Only then, there are reasons to believe that such UAC centre transforms into the growth pole. Thorough analysis of UAC centres' population amount dynamics testified the fact the Poltava Region UACs network has gone unbalanced and got in a state of a crisis. An average 60 % of the region population lives at depressive localities.

In Poltava Region, population amount dynamics' indicators largely correlate with indicators of its migration activity. The last ones have been rather labile indicators, clearly capture the dynamics specificity of the area social-economic development, representing job positions' possibilities and population's self-realization in the localities. The availability and expansion of such opportunities in various localities reveal the acquisition of growth poles by them (Pidhrushnyy, 2013). Almost all of the region towns (except of Poltava, Kremenchuh, and Horishni Plavni) exemplify a negative migration balance, being unfavourable for living and unable to bare the status of area-forming nucleus in modern way of life.

The level of their economic activity is also quite significant indicator of growth poles, which is the correlation between a number of business entities of the centre and corresponding average national indicator. Therefore, Poltava, Kremenchuh, also some small areas around them indicate the highest level of economic activity. The rest of districts of the region outside the regional centres' boundaries hold the status of area with decreased economic activity. One of the specific indicators, highlighting the social-economic growth positive tendencies in certain districts of the region, is the level of FDI volumes, scilicet the amount of foreign investors' equity, invested in business objects, affects the development of social-economic activity centres (Pidhrushnyy, 2017). The

largest FDI volumes are concentrated in Poltava, Horishni Plavni, and Kremenchuh. Areal division of these FDI volumes tends to be extremely uneven in Poltava Region.

Taking into in-depth consideration the criteria and indicators of Poltava Region UACs' centres development, it is fair to note that their groups can be distinguished by the social-economic development poles according to the level of formation in as follows:

1) centres-poles, being under formation;

2) centres, which have some prerequisites to transform into growth poles;

3) centres with insufficient capacity to transform into growth poles.

Up-to-date situation forms a distinct marker the only formed social-economic development poles in Poltava Region are Poltava and Kremenchuh. Such towns as Horishni Plavni, Myrhorod, Lubny, and Hadiach belong to the group of centres, being under formation. Karlivka, Pyriatyn, Lokhvytsa, Zinkiv, Hlobyne, and Kobeliaky have outlined vivid prerequisites to further transformation into growth poles. The remainder, constituted by Velyka Bahachka, Kozelshchyna, Mashivka, Novi Sanzhary, Opishnia, Chornukhy, and Shyshaky, renders a low profile and stands for a group of UACs with insufficient capacity to transform into social-economic growth poles in Poltava Region.

Previously made all-embracing analysis disclosed the fact the majority of Poltava Region regional centres comprises the 2nd and the 3rd groups, been in a state of formation, or has some prerequisites to further transformation into growth poles. Those UACs, constituted by such localities as Bilotserkivka, Butenky, Velyki Sorochyntsi, Drabynivka, Zavorsklo, Zasullia, Klepachi, Kolomatske, Krasna Luka, Lanna, Mala Pereshchepyna, Machukhy, Mykhailivka, Nedoharky, Nekhvoroshcha, Novoavramivka, Novoznamianka, Obolon, Omelnyk, Petrivka-Romenska, Pishchane, Pokrovska Bahachka, Pryshyb, Rokyta, Rudenkivka, Sencha, Serhiivka, Skorokhodove, Tereshky, and Shcherbani, possess low potential ability and low level of formation as growth poles. Actually, they have no appropriate prerequisites and possibilities, even by the previous predication, to transform into growth poles, except of Bilotserkivka and Velyki Sorochyntsi. The spectrum of the mentioned above aspects makes serious challenge and threat to administrative-areal reform implementation on the regional level and acquire system of measures to transform UAC centres into a balanced system of growth poles.

An efficient solution of the regional development issues is closely connected to the growth poles' system formation. It also deeply touches upon the issue of Poltava Region specialization areas of the economic complex. They are these branches that unfold stimulating and at the same time stabilizing effect, broadening development impulses over surrounding territory simultaneously to providing the narrowing of depressive territories. Thus, the base of Poltava Region growth poles' forming lies in the transformation of social-economic activity centres.

Conclusions. The results of the given research open the further possibility to formulate a set of measures, concerning the Poltava Region social-economic activity centres' transformation into the growth poles. They are space clustering on the base of comprehensive application of real terms and resources under mandatory ecosystem balance insurance, environmental quality preservation and restoration, achievement of high life quality and well-being of the population, economy re-industrialization insurance on the new technical and technological basis, innovative economic development implementation, grounded on the smart-specialization, rural areas' monospecialization overcoming. One also can speak about food, light industriesandagriculturalengineering local economic clusters' creation; high-levelled areas' infrastructure potential achieving; priority support of creative industry, recreation, tourism, logistics, and exhibition activity development; usage of material (natural, historical and cultural monuments, sacred objects) and non-material (area brand, labour-resource and innovative-scientific potential) assets, able to make the social-economic increase effects.

Crucial indicators in achieving these goals should provide the population employment growth in non-agricultural activity, the development and implementation of programmes of localities' improvement, and the increase of the comfort of living as well as the level of social-cultural and household services to the inhabitants. Likewise, they are the elaboration and implementation of business plans of areal development, and the creation of innovative clusters and industrial parks for efforts incorporation and competitiveness enhancing.

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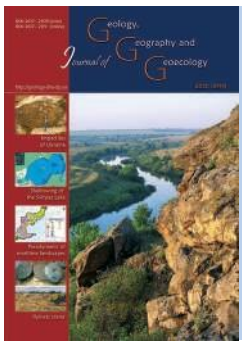

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Agroecological assessment of fluorine in soils and agricultural plants of steppe landscapes of Odessa region

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Abstract. The materials of long-term research of the features of the content and distribution of fluorine in southern chernozems are highlighted. The purpose of this work is to investigate the effects of irrigation and chemical meliorants on the fluorine accumulation in soils and crops. To achieve this goal, the following tasks were set: to determine the content of fluorine in soils and plants in conditions of irrigation and application of phosphorus fertilizers (phosphogypsum); to carry out ecological assessment of southern chernozems in terms of accumulation and migration of fluorine in soil, plant resistance to fluorine accumulation and translocation. The research was conducted within the irrigation areas of Odessa region. Bulk and movable forms of fluorine were determined by the potentiometric method in the southern chernozems of different reclamation state (non-irrigated, irrigated and irrigated reclaimed). The content of movable fluorine in agricultural plants was determined by the author's method. It was established that the contest of bulk fluorine is the highest in the non-irrigated chernozems, but does not exceed the MPC. In irrigation, the number of bulk forms of fluorine decreases due to their dissolution and migration from the top layer to the depth of the soil profile. The content of soluble forms of fluorine increases significantly in all components of agrolandscape under the influence of irrigation and especially the introduction of phosphogypsum. It was determined that the combined application of phosphorous fertilizers and manure leads to a decrease of the fluorine content in soils, lysimetric waters and agricultural plants. The degree of mobility of fluorine compounds in the studied chernozems during irrigation and especially the introduction of phosphogypsum increases. The level of fluorine content in lysimetric waters and the coefficient of water migration correlate with its content in soils. A positive correlation was found between the fluorine content in the roots of maize, oats, wheat ear and soil while its absence between the content of fluorine in the stems and leaves. The introduction of mineral and organic fertilizers together enhances the ability of plants to absorb fluorine from chernozem soils. The active contamination rate for all tested plants is higher than one, which can cause their inhibition. When resuming irrigation of chernozem soils, there will be a need for increased doses of mineral, including phosphorus fertilizers. Despite the low solubility of fluorine compounds, conducted research has shown that irrigation and application of phosphogypsum significantly increases the soluble forms of fluorine, which can adversely affect the pollution of agrolandscapes and public health.

Key words: fluorine, southern chernozem, agricultural plants, ecological assessment

Агроекологічна оцінка фтору у ґрунтах та сільськогосподарських рослинах степових ландшафтів Одещини

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Анотація. Висвітлено матеріали багаторічного дослідження вмісту фтору в агроландшафтах масивів зрошення Одещини. Розглянуто вплив зрошення і хімічних меліорантів на накопичення фтору в ґрунті, лізиметричних водах, рослинах.. Встановлено, що вміст валового фтору в незрошуваних чорноземах південних вищий, ніж на зрошенні, оскільки при зрошенні відбувається поступовий перехід валових форм у розчинні та їх міграція з верхнього шару в глибину ґрунтового профілю. Вміст водорозчинного фтору при зрошенні, і особливо при внесенні фосфогіпсу підвищується, в окремих випадках сягаючи високого рівня. З'ясовано, що ступінь рухливості сполук фтору в досліджуваних чорноземах при зрошенні і особливо внесенні фосфогіпсу значно підвищується. Виявлена відповідна закономірність щодо вмісту розчинних форм фтору в лізиметричних водах та соці досліджуваних сільськогосподарських рослин. Встановлена позитивна кореляція між вмістом фтору в коріннях рослин кукурудзи, вівса, колоссі пшениці і ґрунтах при її відсутності між кількістю фтору в стеблах та листі. Внесення мінеральних і

органічних добрив спільно підвищує здатність рослин поглинати фтор з чорноземних ґрунтів. Показник активного забруднення як при зрошенні, так і зрошенні та внесенні фторвмісних добрив для всіх рослин є вищим за одиницю, що може спричиняти їх пригнічення та негативно впливати на харчовий ланцюг. Незважаючи на низьку розчинність сполук фтору, проведеними дослідженнями з'ясовано, що зрошення та внесення фосфогіпсу значною мірою збільшує вміст розчиннних форм фтору в ґрунтах та сільськогосподарських рослинах. В умовах зміни клімату та необхідності відновлення зрошення чорноземних ґрунтів степової зони Одещини можна рекомендувати проводити систематичний контроль за вмістом розчинних форм фтору у зрошуваних ґрунтах та рослинницькій продукції.

Ключові слова: фтор, чорнозем південний, сільськогосподарські рослини, екологічна оцінка

Introduction. In modern conditions of declining environmental quality, the environmental approach of geographical research becomes a priority when studying both individual components of the nature and the environment in general (Topchiyev et al., 2019). Soil is the most stable component of the environment, in which not only the nutrients of the plant, but also the toxic chemicals accumulate. One of these phytotoxic trace elements is fluorine. Fluoride accumulation in plants depends on the presence of its movable forms in the environment (and especially soil) and the individual characteristics of plant organisms. Fluorine and its compounds are characterized by high chemical activity and are highly toxic (1 hazard class) to soil biota and plants. Excessive content of fluorine in soils is manifested in the change of its physicochemical properties, decrease in fertility, damage to plants, decrease in yield, diseases of animals and humans.

The systematic introduction of mineral fertilizers and chemical meliorants which are used to increase the soil fertility is inevitably related to the introduction of contaminants into the soil. Despite the sharp decrease in the volumes and rates of application of mineral and organic fertilizers in recent decades, the degree of contamination of the irrigated chernozems in southern Ukraine remains high, which is caused by the consequences of the previous long-term chemical melioration of agriculture, the features of lands use and the properties of the chernozem soils.

Fluorine and its compounds have a narrow range of physiologically optimal content. Both insufficient and excess fluorine content can adversely affect living organisms. It is very difficult to determine safe levels of fluorine in soils and crops (Trigub, 2014). The contradiction of numerous studies and opinions of scientists at a level of safe fluorine content in the components of the environment due to the presence of various factors which define toxicity of fluorine and the lack of comprehensive analysis of environmental and hygienic aspects of pollution of the biosphere generally (Trigub and Lyashkova, 2018).

The relevance of the author's study of fluorine compounds in the steppe landscapes of the region is due to the properties of trace elements accumulate in plants and through the trophic chains adversely affect human health.

The purpose of the study is to investigate the effects of irrigation and chemical meliorants on the fluorine accumulation in soils and crops.

To achieve the goal, the following tasks were set: to determine the content of fluorine in soils and plants in conditions of irrigation and melioration of them by phosphogypsum; to carry out ecological assessment of southern chernozem with indicators of accumulation and migration of fluorine in soil, resistance of plants and their organs to fluorine accumulation.

The issues of fluorine translocation from soil to plants are quite fully covered in the literature (Pickering, 1985; Elrashidi and Lindsay, 1986; Trigub and Poznyak, 2008; Jha et al., 2009; Mourad et al., 2009; Tayibi et al., 2009; Perez – Lopez et al., 2010; Smidt et al., 2011; Tandelov, 2012; Lakshmi et al., 2016). However, the analysis of previous studies shows that a single opinion on the accumulation of fluorine in plants depending on its content in the soil, especially in the reclamation of phosphogypsum, has not been developed and is now controversial. The accumulation of fluorine in soils and plants during the application of mineral fertilizers was considered in the works of Kudzin and Pashova (1970), Piotrowska and Miacek (1975), Thompson et al. (1979), Pashova (1980), Baranovsky and Pankrutskaya (1992), Kabata-Pendias and Pendias (1989), Loganathan et al. (2001), Weinstein and Davidson (2004), Tandelov (2012), Trigub, Poznyak (2014), and others. Systematic application of phosphorus fertilizers and phosphogypsum in large doses causes an increase in fluorine content in chernozem soils (Trigub and Poznyak, 2014). The question is whether plants are enriched with fluorine from soils which contain it in large quantities? Kabata-Pendias and Pendias (1989) tend to conclude that the fluorine content in plants does not depend on its content in soils. However, this conclusion is not sufficiently substantiated, as it concerns the results of determinations of sparingly soluble (gross) forms of fluorine. According to Holevas (1960), some tropical soils may contain organic fluorine compounds, which are easily available for plants and highly toxic for animals. According to Piotrowska and Miacek (1975), Thompson et al. (1979), Pashova (1980), Trigub and Poznyak (2008), Mourad et al. (2009), Tandelov (2012) enrichment

of soils with fluorine-containing mineral fertilizers leads to an increase in its content in crop yields. The relationship between the quantitative content of fluorine in soils and plants is defined in the works of Haidouti et al. (1993), Davis (1995), Tandelov (2012), Trigub and Poznyak (2014). In climate changing conditions and the urgent need for irrigation of soils of the steppe zone of Ukraine, the problem of fluorine pollution of chernozem soils and agricultural plants is relevant and needs further study.

Materials and methods of research. The following methods are applied in the work: field, laboratory, measuring, calculation and comparative, data graphical display. The studies were conducted using techniques and methodological approaches certified and standardized in Ukraine (Metodicheskiye ukazaniya…., 1975; Yakist gruntu…, 2004; Baliuk et al., 2013).

Studies on the influence of irrigation and phosphogypsum application on the fluorine content in chernozem soils and agricultural plants were carried out within the irrigation arrays of Odessa region (Fig. 1). In 1993-1995, soil scientists of Odessa University under the leadership of I.M. Gogolev established an experimental network of long-term soil and ecological monitoring sites on irrigation

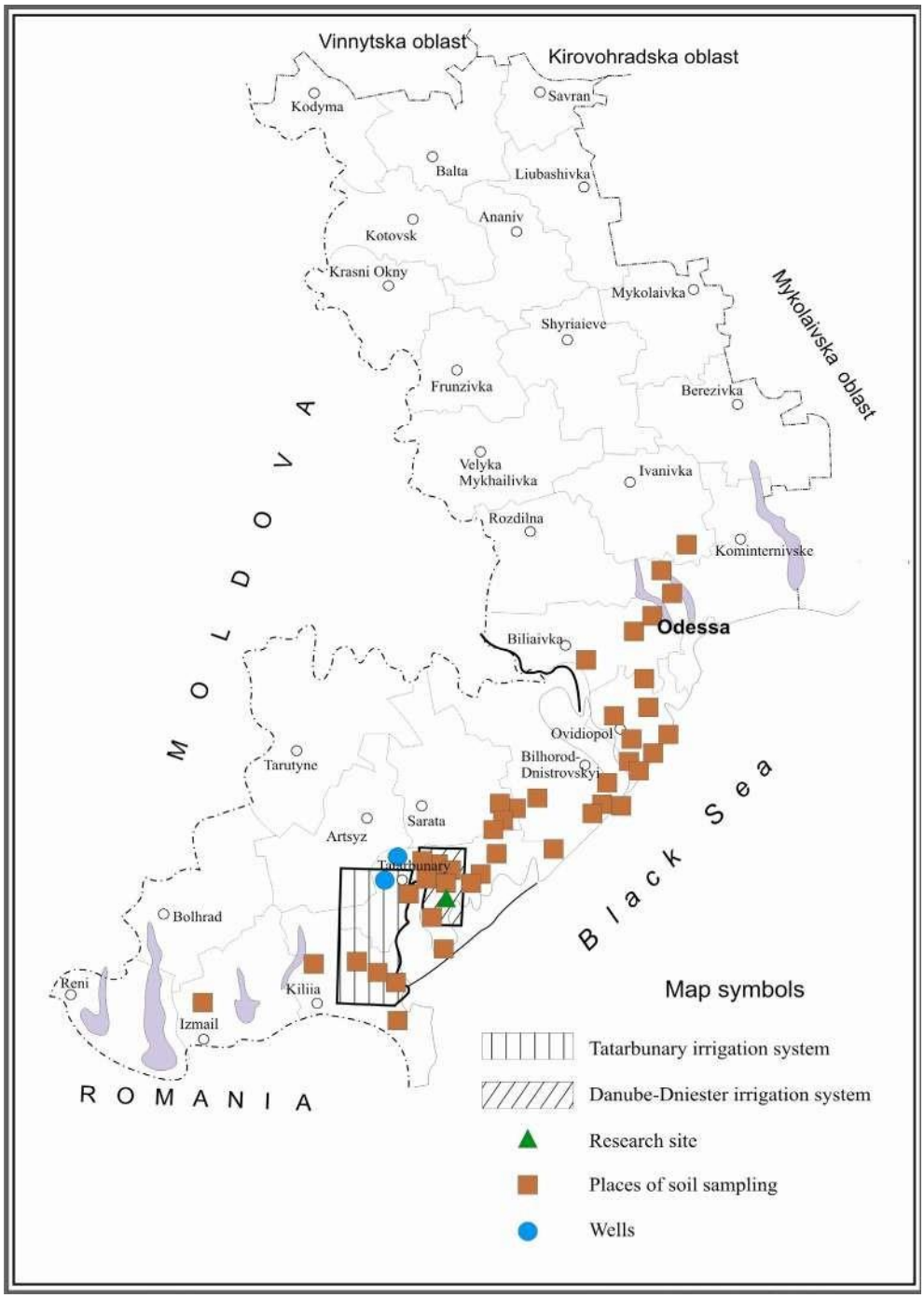

Fig. 1. Map of the studied area

areas (IA) of Odessa region. The plots differ in landscape and reclamation conditions and genetic and reclamation and production properties of the original (before irrigation) chernozem soils, the duration of the period of more or less intensive and systematic irrigation and the subsequent period of its cessation and extensification of agriculture in the last 25 years. In modern conditions, regular (or even periodic) watering is carried out on an area of not more than 10-20 times, up to 30% of irrigation developed lands in previous years. However, even today, monitoring sites annually conduct research on the evolution of soils and lands under conditions of irrigation, as well as the cessation and post-irrigation evolution. Monitoring studies also include studies of fluorine in agrolandscapes of irrigation areas (Chornozemy` masy`viv ….., 2016).

Soil contamination can be controlled by the content of both bulk and movable elements. The vast majority of fluorine in soils (up to 95%) is in the form of poorly soluble compounds (Perelman, 1989). Although, it is mostly affected by soil properties and living organisms, such as water-soluble forms of fluorine.

Studies on the effects of irrigation and phospho-gypsum introduction on fluorine content in chernozem soils and agricultural plants were conducted within the irrigation areas of Odesa region. In soil samples, the bulk and active (acid-soluble and water-soluble) fluorine were determined using potentiometric method, in plants, the active forms of fluorine were determined by the author's method (Trigub, 2019).

In order to determine the vertical migration of fluorine in the studied area, lysimeters were installed at depths of 30 and 60 cm. Sampling of lysimetric waters was performed three times per a year – in spring, summer and autumn. The fluorine migration ability (coefficient of water migration) was determined by the ratio of the number of element atoms that passed into the mobile state (water) to the number of its atoms in the soil (Kovda, 1973).

Ecological evaluation of the studied soils and plants was performed according to the indicators of accumulation and migration of fluorine in the soil, resistance of the plant to the accumulation and translocation of fluorine (Ilyin and Stepanova, 1979, Baliuk et al., 2013).

Results of the studies and their discussion. Phosphorus is one of the important elements of root plant nutrition on irrigated chernozems. Phosphorous fertilizers which are used in agricultural production (superphosphate, double superphosphate, precipitate, etc.) always contain more or less biologically toxic fluorine in their composition. There are different opinions about the possibility of soil contamination with fluorine due to irrigation and prolonged use of phosphorus fertilizers.

According to our researches, in the upper horizons of the southern chernozems, the samples of which were collected on the irrigation areas (IA) of the Odessa region of Ukraine (Fig. 1), the bulk fluorine content ranges from 310.0 to 597.0 mg/kg (Fig. 2). The content of bulk fluorine in

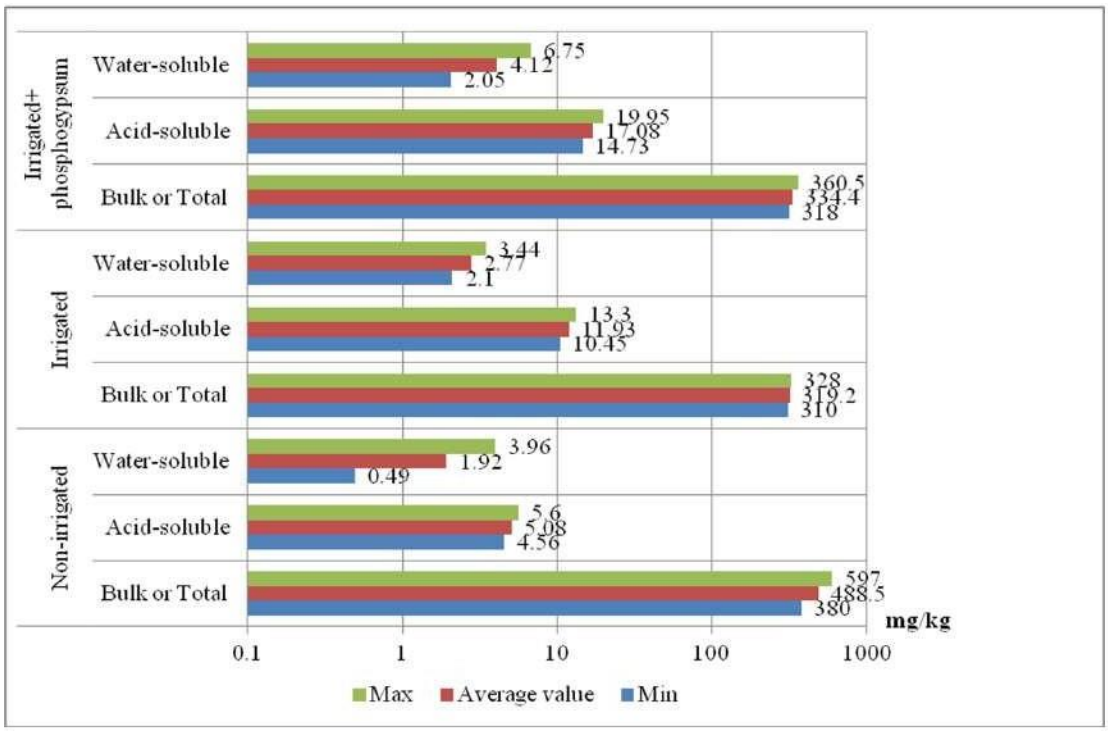

Fig. 2. The content of fluorine in the arable layer of southern chernozem irrigation areas of Odessa region (mg/kg)

southern non-irrigated chernozems is higher than in the irrigated ones, which is caused by additional moisture. During irrigation, there is a gradual transition of the bulk forms into soluble ones and their migration from the upper layer to the depth of the soil profile. During irrigation and gypsuming, the amount of bulk fluorine increases, but not considerably.

The content of soluble forms of fluorine in the arable layer of the southern chernozems IA of Odesa region varies widely: acid-soluble − 4.56-19.95 mg/kg, water-soluble − 0.49-6.75 mg/kg. The lowest levels of fluorine are observed in non-irrigated chernozems, the highest – in those irrigated with gypsum (Chornozemy` masy`viv…., 2016).

The increase in the content of movable fluorine concentrations in irrigated soils, compared to their bulk content, indicates an increase in its mobility, migratory capacity, and increased risk of flow into plants, the possibility of migration to the lower horizons of the soil and groundwater, which needs to be constantly controlled to prevent negative consequences in soils, groundwater and plants.

Investigation of the profile distribution of fluorine has shown that the content of bulk fluorine varies within 320-670 mg/kg, and in non-irrigated lands its content in the upper layer is much higher than that on the irrigated ones. Downwards the soil profile and forest thickness, the content of the bulk fluorine increases, reaching 600-800 mg/kg, in some cases 1000 mg/kg. There were no differences between non-irrigated and irrigated soils deeper than the lower boundary of the profile.

The high content of soluble forms of fluorine in the upper horizon of southern chernozem, especially in non-irrigated ones, can be explained by the biological accumulation of this element. In the subirrigated horizon, the content of fluorine decreases slightly. The highest concentrations are typical for carbonate accumulation horizons. There is a natural increase in the concentration of active fluorine downwards the profile: at a depth of 140-150 cm it reaches 25-30 mg/kg, which is associated with an increase in its bulk forms. The maximal values of fluorine content are confined to soil-forming rocks.

Researches on fluorine accumulation in soils with the systematic application of fluorinated fertilizers are highlighted in the works of Pashova (1980), Pomazkina (2004), Trigub and Poznyak (2008), Mourad et al. (2009), Brindha et al. (2011), Tandelov (2012).

Versatile researches of the influence of irrigation and gypsum at fluorine content in soil, groundwater and crop products were conducted within the Danube-Dniester IS in the field experiments (Fig. 1). The objects of the study were southern chernozems of warm southern European facies irrigated with low-mineralized waters. In the studies conducted, the main attention was paid to the study of the content of active fluorine, because this form of the microelement is the most toxic to the food chain. Phosphogypsum containing 2% (20000 mg/kg) of total fluorine and 0.3% (3000 mg/kg) of water-soluble fluorine was used for the amelioration of the solentzic chernozems in the southern Danube-Dnestrovsk IS. Therefore, with the introduction of 10 t/ha of phosphogypsum, about 30 kg/ha of active fluoride is introducted into the soil, which can cause an increase in its content in the soil.

According to the results of our research, under the influence of irrigation, the concentration of bulk fluorine in the arable layer in the irrigation area decreased by 60 mg/kg, in the subarable layer 72 mg/kg, which can be explained by the gradual dissolution of the bulk forms and prolonged migration of water-soluble fluorine from the upper layer to the bottom of the soil profile. The content of water-soluble fluorine in the arable layer is the lowest in non-irrigated chernozems (Fig. 3). During irrigation, and especially during irrigation and gypsuming, the content of movable forms of fluorine in the arable horizon increases. With the addition of phosphogypsum, in combination with manure, the fluorine content decreases, because the organic matter of manure is capable to form poorly soluble complexes with fluorine.

According to the classification of irrigated soils by the content of water-soluble fluorine (Baliuk et al., 2013), non-irrigated chernozems of the studied area have low level (0-3 mg/kg), irrigated − mainly average level (3-6 mg kg) and during irrigation and introduction of phosphogypsum, fluorine content increases, in some cases reaching a high level (6-9 mg/kg).

Consequently, the introduction of phosphogypsum into irrigated chernozems increases the content of water-soluble and acid-soluble fluorine, but its absolute values remain, at the same time, lower than the level of MPC. Studies conducted confirm that, despite the low solubility of fluorine compounds ($2.1\ 10^{-3}$ %) in chernozem in the process of irrigation, there is a gradual dissolution occurs, which leads to an increase of the active forms, especially acid-soluble fluorine (almost by 3 times). The increase of movable fluorine concentrations in irrigated soils, compared to their bulk content, indicates an increase in its mobility, migratory capacity, increase of the risk of flow into plants, the possibility of migration into the lower horizons of the soil and groundwater, which requires constant monitoring to prevent negative consequences in soils, groundwater and crop plants.

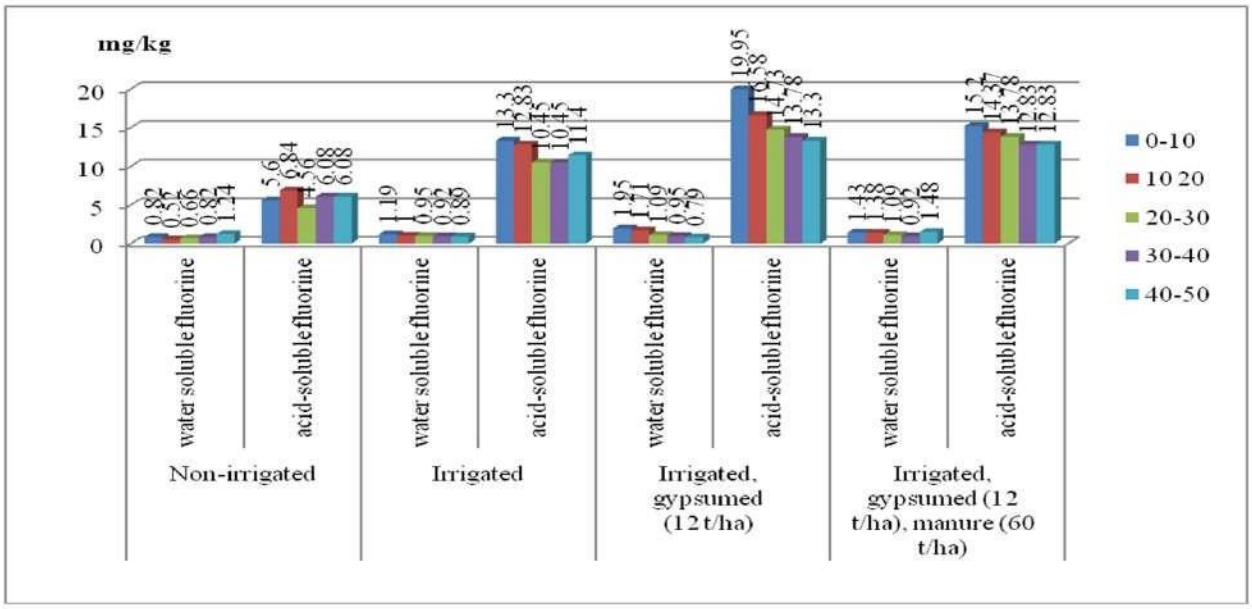

Fig. 3. The content of active fluorine in southern chernozem of Danube-Dniester IS, mg/kg

The dynamics of the content of active fluorine in the southern chernozem of the Danube-Dniester IS is presented in the Fig. 4 and the Fig. 5. As it is clear from the figures, that during irrigation (Fig. 4) and especially during irrigation and gupsuming (Fig. 5), the activity and, consequently, the mobility of fluorine in the upper layer of chernozems increases from year to year, creating a threat of contamination for geochemically dependent landscapes, natural and groundwater, plant products with this element.

As can be seen from the Figures 4 and 5, the irrigation of chernozems leads to redistribution of fluorine in the soil profile and increase the concentration of its active forms in the arable layer. The systematic introduction of phosphorus fertilizers and phosphogypsum in high doses leads to an increase of fluorine content in soils, especially its active forms (water-soluble and acid-soluble).

Among the negative effects of irrigation and the introduction of phosphate fertilizers is the accumulation of fluorine not only in the soil, but also in surface waters. The accumulation of fluorine in groundwater is influenced by the degree of mobility of fluorines (MF), which may increase with additional

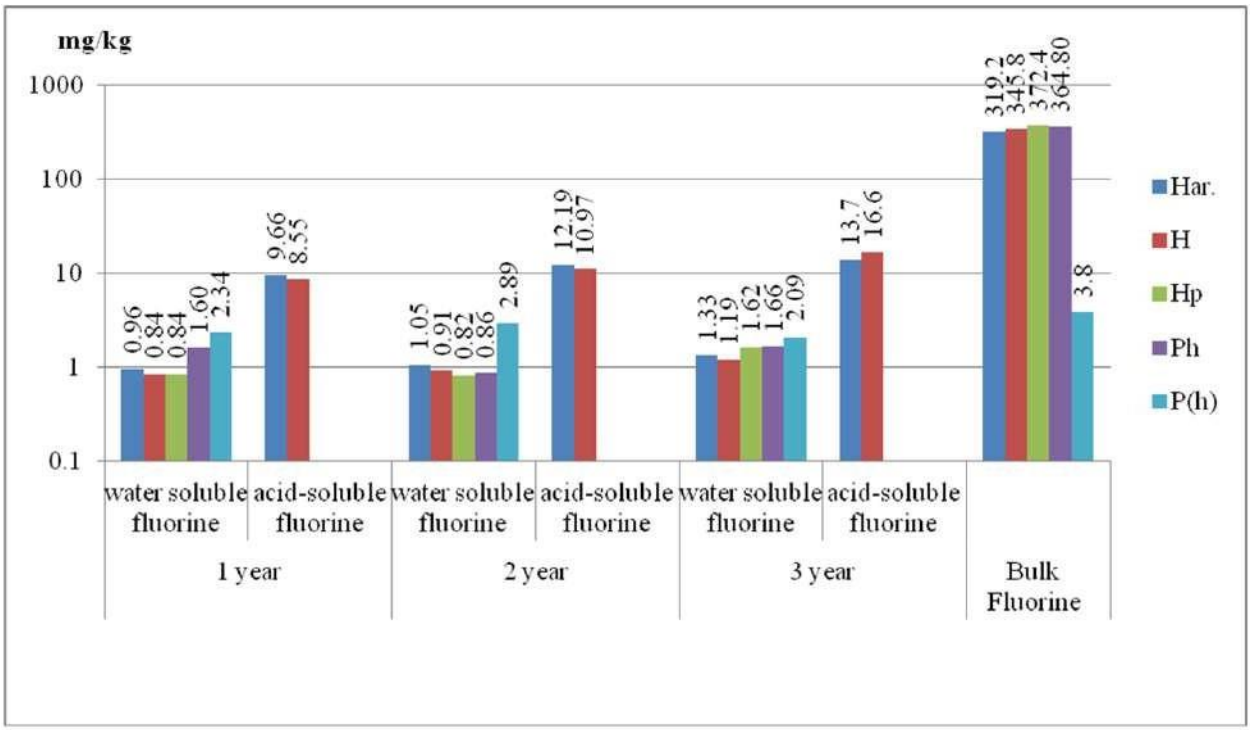

Fig. 4. Dynamics of the content of active fluorine in southern chernozem of the Danube–Dniester IS, mg/kg

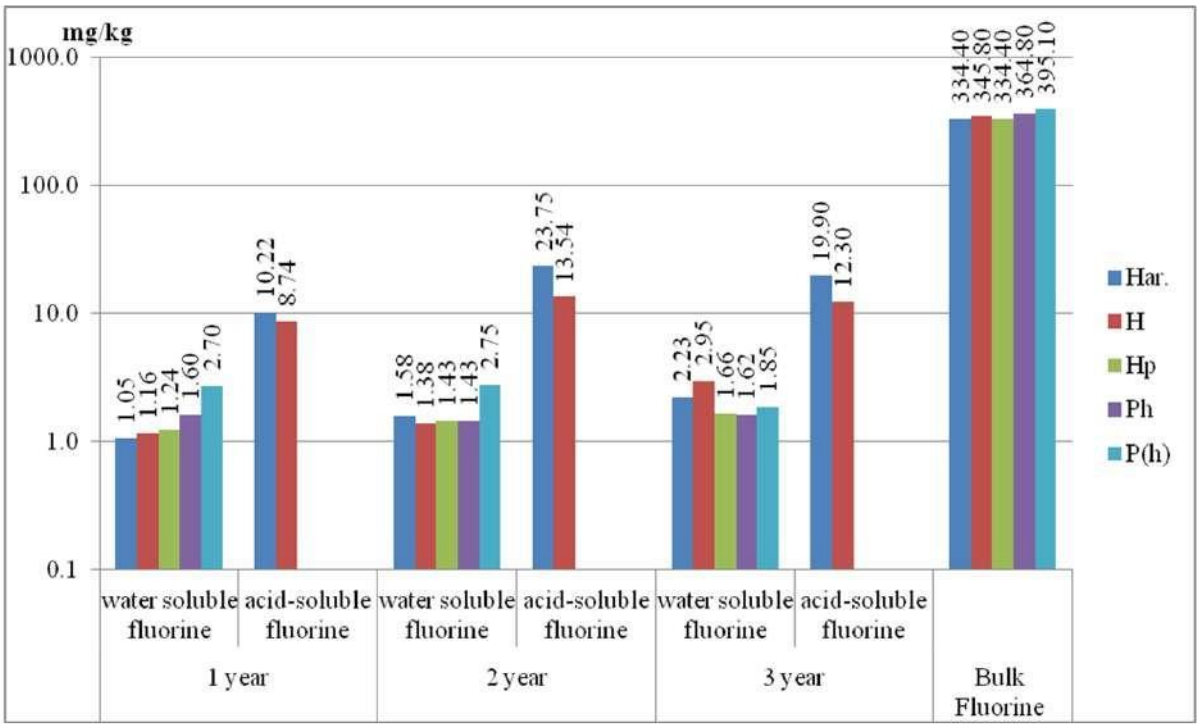

Fig. 5. Dynamics of the content of active fluorine in southern chernozems of the Danube–Dniester IS during irrigation and gypsum, mg/kg

hydration (irrigation) and the introduction of fertilizers containing fluorine compounds. The degree of mobility of fluorines is calculated by the ratio of the content of soluble forms of fluorine to their bulk content in the soil (Pomazkina, 2004). Despite the low solubility and mobility of fluorine in chernozem soils, when the phosphogypsum was introduced, the degree of mobility of water-soluble fluorine increased by 2 times, while the acid-soluble fluorine by 1.5 times (Fig. 6).

To determine the intensity of migration of fluorine through a profile, its content was investigated in lysimetric waters. The study of the composition of lysimetric waters allows to determine the degree of anthropogenic influence on soil processes, to identify patterns of movement of contaminants in soils, to evaluate soil as a natural filter for chemical elements and their compounds, as well as to establish their influence on the composition of groundwater, which is formed due to soil runoff (Zeidelman, 2008).

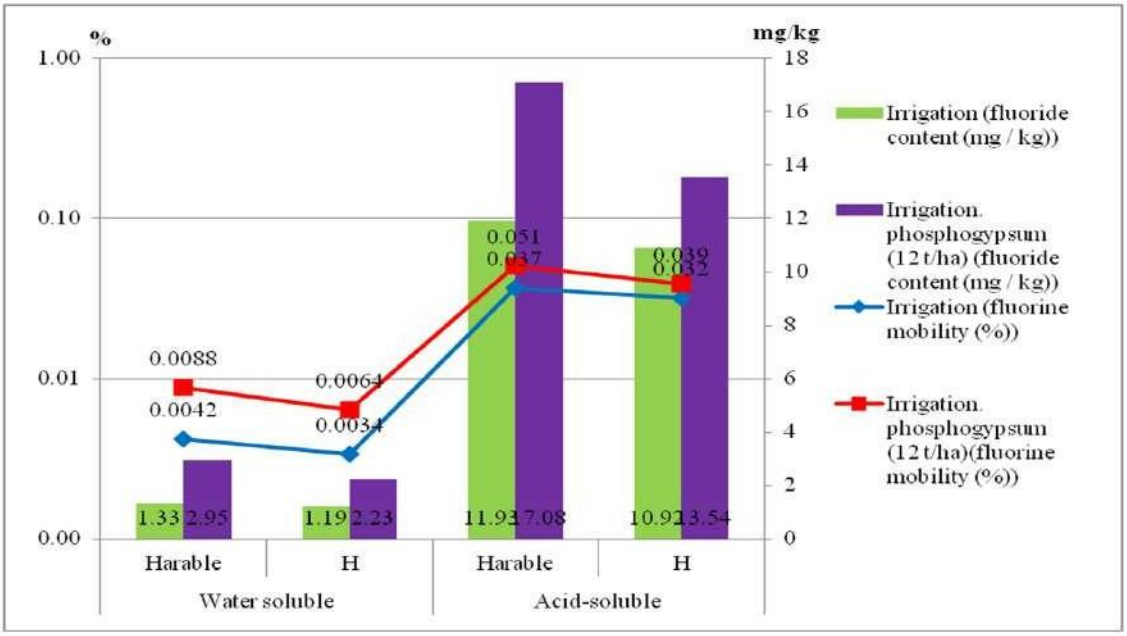

Fig. 6. Content (mg/kg) and mobility index (%) of fluorine compounds in chernozems.

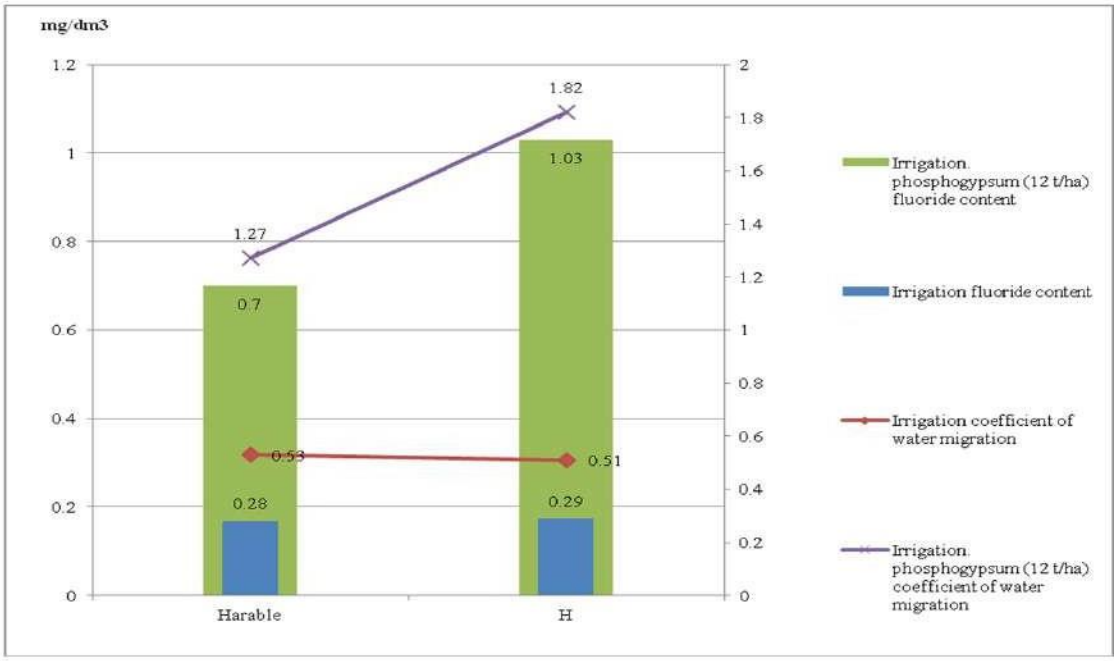

Fig. 7. The content of fluorine (mg/dm^3) and the coefficient of water migration in the system "chernozems-lysimetric waters"

The investigation of the fluorine content in lysimetric waters showed that in case of irrigation (without fertilizing) its contents ranged within 0.13-0.22 mg/dm^3, which is by 1.5-3.0 times lower than the fluorine content in irrigation water (0.43 mg/dm^3). Thus, field studies of lysimetric waters confirmed the high absorbing capacity of chernozem soils in relation to fluorine compounds contained in irrigation water.

In irrigated areas where phosphogypsum was introduced, the fluorine content in lysimetric waters increased significantly, in some cases reaching over 1 mg/dm^3 , due to the high migration activity of the microelement element and the additional supply of its compounds with ameliorants (Fig. 7).

The conducted studies are confirmed by the calculations of the fluorine migration activity in the lysimetric waters of experimental sites (during irrigation and introduction of phosphogypsum). The coefficient of water migration of fluorine increased by 2.5-3.5 times during the introduction of phosphogypsum, which can lead to significant contamination of groundwater and its accumulation in plants.

Thus, the degree of mobility of fluorine compounds in the studied chernozem increases with irrigation and especially the introduction of phosphogypsum. The level of fluorine content in lysimetric waters and the coefficient of water migration correlate with its content in soils and can serve as a source of contamination of groundwater and plant products.

Scientists pay considerable attention to the study of fluorine migration in the soil-plant system, especially while applying fluorine-containing fertilizers. However, there is no general opinion regarding the dependence of fluorine content in soils on its content in plants. Natural fluorine is inaccessible to plants, so its content is insignificant. The average fluorine content in plants is 0.1-5.0 mg/kg of dry matter and can range from zero to several hundred milligrams. In areas distant from industrial enterprises, the maximum content of fluorine in plants (depending on the types) is 10-20 mg/kg of dry matter, which makes 0.001-0.002%. Compounds of fluorine entering the soil under conditions of technogenic pollution, unlike natural ones, are easily soluble and can be actively accumulated by plants (Orlov et al., 2002). Due to the high chemical activity and the danger for the health of plants and animals, the content of fluorine in plant products is normalized. The maximal permissible concentrations of fluorine in food of plant origin (bread, vegetables, fruits) is 2.5 mg / kg, in green fodder and hay − 20 mg / kg of dry matter. But the general (reserve) content of slow-moving fluorine is normalized. Moving fluoride is dangerous, which is readily stored in living organisms. The introduction of fluorine-containing fertilizers can lead to the accumulation of movable forms of fluorine.

The available scientific literature on the effect of fluorine on crop yields has considerable controversy. Some scientists note the positive effect of fluorine on plants (Pashova, 1980). According to others (Kabata-Pendias and Pendias, 1989) − fluorine is not

an essential element for plant development. The high content of fluorine in soils is toxic for plants (Nowak et al., 2000; Rezaei et al., 2017) and impairs their growth and properties (Cui et al., 2011). The negative effects of fluorine on plants are manifested, for example, by chlorosis (yellowing) and necrosis of leaves, as well as a decrease in chlorophyll content, resulting in inhibited plant growth (Weinstein and Davidson, 2004). Found that mineral fertilizers increase the fluorine content in the upper soil horizons and agricultural plants. There is no definite relationship between the concentration of soluble fluorine in soil and their content in plants. According to Kabata-Pendias and Pendias (1989) there is no correlation between the bulk fluorine content in soil and plants. Other scientists (Pashova, 1980; Pomazkina, 2004; Tandelov, 2012) have found that mineral fertilizers increase the fluorine content in the upper soil horizons and agricultural plants.

Fluorine-containing fertilizers are one of the main factors for the contamination of agricultural plants with fluorine (outside of industrial exposure). However, the response of plants to the introduction of increased amounts of fluorine into the soil is not straightforward and requires studies of the patterns of absorption of fluorine compounds by plants. The ability of plants to absorb fluorine from the soil is characterized by a biological absorption coefficient (BAC), which shows the ratio of fluorine content in the sol of the plants to the content in the upper (root) horizon of the soil (Perelman, 1989). It is established that the average value of BAC for cultivated plants is 0.2 (Perelman, 1989). However, these definitions concerned the total content of the microelement and not its movable forms.

Our field researches have shown that while irrigation, the content of movable fluorine in various agricultural plants and their particular organs ranged from 0.06 to 0.20 mg/l. With the introduction of phosphogypsum in irrigated chernozem, the content of fluorine in the sap of plants increased significantly − 0.12-0.74 mg/l. When introduced together with mineral and organic fertilizers, the fluorine content ranged from 0.12 to 0.42 mg/l (Fig. 8). Therefore, the introduction of increased doses of fluorine-containing fertilizers lids to an increase of the movable forms of fluorine in all the agricultural plants and their particular organs. In our opinion, this is due to the flow of fluorine directly to their fertilizers even before absorption by the solid part of the soil. A corresponding pattern was also found in the determination of fluorine in soil samples and lysimetric waters.

The calculations of the biological absorption coefficient of the movable forms of fluorine, that is the level of plants' ability to absorb fluorine from the soil, had sufficient differences between particular agricultural plants and their organs (0.05-0.15). The highest index BAC belongs to the wheat ears − 0.33 as well as the corn and oats − 0.22, which were higher than the average values for cultivated plants. Therefore, the ability of plants to absorb soluble fluorine from the soil while applying fertilizer is high, can affect the quality of crop products.

Studies have shown a positive correlation between the content of fluorine in the roots of maize, oats, wheat ears and soils in the absence of fluorine in the stems and leaves.

BAC in plants grown in areas where fluorinated and organic fertilizers were jointly introduced was the

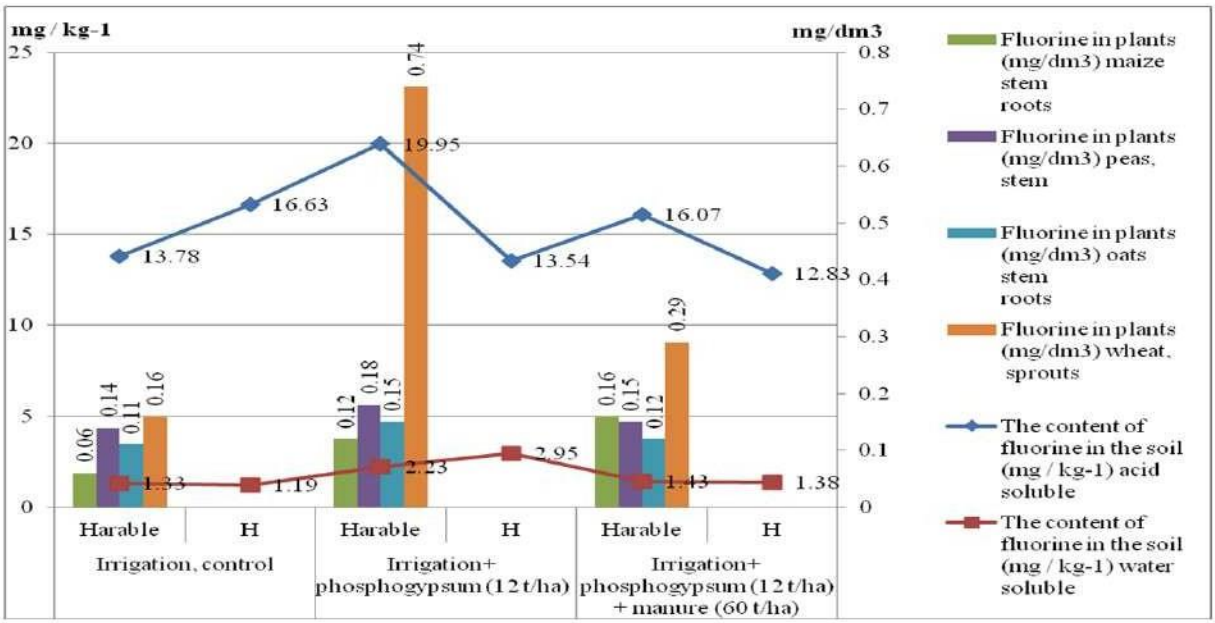

Fig. 8. The content of fluorine in soils (mg/kg) and plant cell sap (mg/dm^3).

highest in almost all plants and their organs (except wheat ears). Thus, the roots of corn and oats had a BAC of 0.25 and 0.29, respectively.

Therefore, the quality of irrigation waters and the degree of contamination of irrigated soils quite naturally affect the concentration of fluorine in agricultural plants and, accordingly, the quality of production.

Based on the information given in the article, it can be predicted that the danger of contamination of the chernozem soils of the studied area will disappear if the tendency of coagulation irrigation and the decrease of phosphorus fertilizers introduction in the present conditions, as well as the need for phosphogypsum application are eliminated.

However, irrigation is one of the most effective methods to improve productivity of agricultural crops for the areas with arid climate. These issues are particularly relevant in the conditions of climate warming. It is known that at optimal irrigation rates the aqueous, thermal regime of soils improves, their microbiological activity increases, and the biological productivity of agrolandscapes increases (Gogolev et al., 1992; Naukovi osnovi..., 2009).

When restoring irrigation of chernozem soils, especially in of southern territories of Ukraine, there will be a necessity of introduction fertilizers and meliorants. In modern conditions, the most promising for irrigation is drip irrigation, especially for fruit, vegetables and grapes, which combine irrigation with the use of chemicals, including the introduction of mineral fertilizers, meliorants and microelements. However, fertilizer application with irrigation water not only increases the efficiency of fertilizers for plants, but also affects the solubility of various biologically active substances. Despite the low solubility of fluorine compounds, studies haveshown that irrigation and the introduction of fluorinated fertilizers greatly increases the soluble form of fluoride, which can negatively affect the pollution of agrolandscapes and health of the population.

Conclusions.

Thus, the studies carried out show that:

1. Irrigation and chemical melioration is a significant factor in the differentiation of the territory by the content of bulk and water-soluble fluorine in the southern chernozems. Irrigation and introduction of phosphogypsum leads to the accumulation of active fluorine in the "southern chernozems-plants-groundwater " system. The content of active fluorine in the plant sap depends on its content of soluble forms in the soil.

2. As the flow of fluorine with phosphorous fertilizers, meliorants and irrigation water creates an additional risk of contamination with this element of agricultural production, it is advisable to monitor systematically the content of water-soluble fluorine in irrigated soils and crop products.

3. In order to grow ecologically pure crop products and prevent toxic effects of the microelement on organisms of animals and humans, it is recommended to add fluorine to the list of indicators which are subject to compulsory control in the certification of agricultural products, especially its soluble forms.

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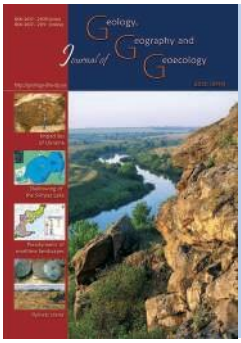

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The maritime para-dynamic as a phenomenon of the formation of the landscape space

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Abstract. The coastal zones are characterized with the considerable variety and the specificity of the landscapes. Their properties and the structure are determined with the interaction of the water area and the dry land. Here the natural and the anthropogenic components of the landscapes come into the close interaction with each other with the useful (microclimate, energy potential of breeze) and the inauspicious (storms, costal abrasion, high corrosive activity) consequent for the landscape structures and the maritime nature use. The determination of such interaction and their consequences are the aim of this article. The method of the analysis and the synthesis of the empirical data is determined. This is due to the considerable dispersion of the geophysical and the geochemical data by the branches and the spheres of the research. So, the collection of the diversified data, their processing and the interpretation have become the important component of the method. The method of the conjugate analysis of the components has given the possibility to catch out the dependence between the processes and the appropriateness in the "process-result" chain. It is studied out that the unity of the dry land and the marine components of the coastal zones is insufficiently studied. It is explained with the complicated character of the interaction between the coastal landscapes and the considerable versatility of the interaction between the coastal dry lands and the water area of the seas. The fragmentary character and the dispersion of the primary information on the dynamics of the coastal landscapes complicate the process of the research of such interaction. It should be noted, that the integration between the theories of the research of the dry land and the sea is still weak. The main complexity is that for now the structure of the process monitoring in the dry land and in the sea is different and it does not promote the integration of these researches. It is installed that the different in the structure and the functioning of the landscape has been formulated in the coastal zone of the seas. It is caused with the combination of the natural factors (microclimate, coastal abrasion and accumulation, infiltration of the marine waters, salt metabolism) with the maritime activity of the human (fishing, recreation, sea transport, tourism). It has been proved that all kinds of the dynamics between the contrasting environments, including the coastal areas, we can attribute to the para-dynamics. The processes of the interaction of the dry lands and the water areas within the coastal zones are determined with their geomorphological, microclimatic and migratory components. They can be happened through the migration of the ions, the salts and their solutions, the display of the breeze circulation, humidity of the air, the migration of the living organisms and others. The variety of the interaction is heightened with the high dynamism of the coastal processes. It is caused the high variability and the dynamic lithomas, which are connected with the surfing and the increase or the decrease of the water activities of the sea water. The surfing of the sorting of the bottom sedimentary and the formation of the zones of the variegated sedimentary in the different distance of the coastal are happened. The move of the coastal-marine drifts along isobathes of the coastline slope is found, which on the dry land physically cannot be in progress. More intensive comparatively with dry land migration of the soil solution is installed, which slows the formation of the soil coverage of the coastal zone. It is installed, that in the basic of the paradigm lies the material, the energetic and the informational exchange between the dry land and the sea. The number of the multidirectional material-energetic flows and the transpositions is disclosed in the coastal zone such as longitudinal and diametrical. The availability of the hydrogenous, the wind-circulation, and hemogeneous interactions were analyzed and reinforced with the examples. The result of such interaction is the diversified formation such as from the features of the relief to the increase of the concentrates and the complexes of the living organisms. The features of the energy paradigms in the coastal areas of the sea are revealed. The large number of the energy flows is directed from the dry land near the sea.

Keywords: interaction of the dry land and sea, contrast environment, coastal zone, substance, para-dynamics, energetic interaction, the Sea of Azov

Приморська парадинаміка як феномен формування ландшафтного простору

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Анотація. У межах берегових зон ландшафти та акваландшафти більш різноманітні. Їх властивості і структура визначаються взаємодією акваторії та суходолу. Туг природні та антропогенні складові ландшафтів вступають у тісні взаємодії між собою з корисними (мікроклімат, енергетичний потенціал бризів) та несприятливими (шторми, берегова абразія, висока корозійна активність) наслідками для ландшафтної структури та приморського природокористування. Встановлення таких взаємодій та їх наслідків є метою даної статті. З'ясовано, що єдність суходільної та морської складових берегових зон до цих пір є слабо вивченою. Це пояснюється складним характером взаємодії між прибережними ландшафтами та значною багатогранністю взаємодій між прибережними суходолом і акваторією моря. Фрагментарний характер та розпорошеність первинної інформації по динаміці прибережних ландшафтів ускладнюють процес дослідження таких взаємодій. Встановлено, що у прибережній зоні морів формуються відмінні за структурою і функціонуванням ландшафти. Це спричинено поєднанням природних факторів (мікроклімат, берегова абразія та акумуляція, інфільтрація морської води, сольовий обмін) з приморською діяльністю людини (рибальство, рекреація, морський транспорт, туризм). Доведено, що усі види динаміки між контрастними середовищами, в тому числі й прибережної, слід відносити до парадинаміки. Процеси взаємодії суходолу та акваторії у межах прибережної зони визначаються їх геоморфологічною, мікрокліматичною та міграційною складовими через міграцію іонів, солей та їх розчинів, прояв бризової циркуляції, вологість повітря, міграцію живих організмів та ін. Різноманіття взаємодій посилюється високою динамікою прибережних процесів. Встановлено, що в основі парадинаміки лежать речовинні, енергетичні та інформаційні обміни між суходолом та морем. У прибережній зоні виявлено ряд різноспрямованих речовинно-енергетичних потоків і переносів – поздовжніх і поперечних. Проаналізована і підкріплена прикладами наявність гідрогенних, вітроциркуляційних, хемогенних взаємодій. Виявлені особливості енергетичної парадинаміки у прибережній зоні моря.

Ключові слова: взаємодії суходіл-море, контрастні середовища, берегова зона, речовинна парадинаміка, енергетична взаємодія, Азовське море

Introduction. The coastal water surfaces and the maritime territories are the important for the preservation of the landscape and the biological diversity, for the development of the traditional nature use. The coastal zones diversify the landscapes of the earth surface. The natural and the anthropogenic components of the coastal zones enter close interaction with each other with the different consequences, mostly with useful for the maritime nature use (the coastal energy, the industrial fishing, the maritime transport and the trade, the recreation and the tourism, the microclimate), and in some cases it is unfavorable (the storms, the coastal abrasion, the high corrosion activity of the maritime environment and others).

Despite the main role in the nature and the economy, the coastal zones in the unity of their dry land and the marine components still remain not enough studied spatial structure. This is due to the complex character of the interaction between the coastal landscapes and the significant versatility of the interactions between the coastal dry land and the water surface of the sea. It is the weak elaboration of the methodological-methodical bases of the research of the para-dynamic interactions and the properties of the landscapes which are caused by them. The difficulties of the study are largely due to the fragmentary character and the scattering of the primary information as for the dynamics of the coastal landscapes in its wide understanding.

The coastal zone of the sea as one of the brightest contacting zones of the geographical space is researched for many decades by the representatives of the different branches of the scientific directions (geomorphology, geology, climatology, hydrology, soil science, geochemistry, geophysics, botany, zoology, etc.) in the unity of its terrestrial and the water composition. Despite this, in the geophysical, the geochemical and in the landscape relations, it as an integral natural-economic complex has been partially researched to date. This is due to the fact that until recently, the shore, as the part of the dry land, and the coastal zone of the sea, as the part of the water surface have been considered separately by the specialists - even within the different classes of the landscapes.

The same belongs to the borders of the Ukrainian Pryazovia, where the scientific investigations have often the isolated component character. Even in the grounded works on the problems of the Sea of Azov and its basin, the geomorphological interactions are highlighted more. And in some cases the sea is considered detached from the surrounding dry land. Instead, the sea-coast of the Sea of Azov has its own unique territorial and the aquatorium landscape features, formed as the result of the common conjoint interaction of the contrasting natural environments and the anthropogenic factors.

It should be noted that among the significant diversity of the scientific and the popular science works on the Sea of Azov and the adjacent to it the dry land, there are many publications that reflect one or another aspect of their interaction. The geological interactions (Shnyukov, 1974; Shujskyj, 2001), the geomorphological (Artyukhin, 2007; Ivanov, 2008; Mamykina, 1980; Shujskyj, 2015; Zenkovych, 1980), the hydrological (Bronfman, 1979; Bronfman, 1985; Symov, 1989), the hydro-meteorological (Ilyin, 2016; Ilyin, 2009), the biogenic (Matyshov, 2011; Aleksandrov, 2011; Vynogradov, 2012), the processes of the pollution (Bespalova, 2007; Ivliyeva, 2007) and others have been explored and have been highlighted in the literatures.

The basics of the research of the interaction

between the contrasting environments, including in the coastal zone of the sea has been put in the article of A.O. Grygorjev (1952). Later, this idea as for the interaction of the oceans and the continents have been developed by K.K. Markov (1968). The basics of the doctrine of the paradynamic-paragenetic interactions, including in the coastal zone of the sea have been formulated and have been developed in the works of F.M. Milkov (1966, 1977, 1981).

In our opinion, the best individual direction of the interaction of the dry land with the water surface of the sea through the shoreline have been reflected in the works of V.P. Zenkovich (1958, 1967, 1980), T.A. Ajzatullin and with the co-authors (Ajzatullin, 1984), G.G. Matyshov (2000, 2008, 2010, 2011), Yu.M. Gargopa (2003), V.O. Dergachev (1987), I.V. Agarkova-Lyax (2006), Yu.A. Zhdanov and with the co-authors (Zhdanov, 1987). The role of the anthropogenic factors in the development of the coastal zone of the sea is highlighted in the works of E. Bird (1990), Yu.V. Artyukhin (1989, 2007), V.I. Lymaryev (1986).

The idea of the existence of the para-dynamic connections between the contrasting environments of the landscape complexes was formulated by F.M. Milkov in 1966 and was improved until the 90s of the last century. At present, the development of the idea of F.M. Milkov about the para-dynamic landscape complexes has been connected with the scientific researches of the scientific schools under the guidance of F.M. Milkov in Russia and his student G.I. Denysyk in Ukraine. The theory of the para-dynamic connections in the positional-dynamic landscape territorial structures has been formulated and has been developed by M.D. Grodzynskyi (1993). The paradynamic connections and the properties in the landscapes have been explored by V.B. Mikhno, K.M. Diakonov, V.I. Fedotov, G.I. Denysyk, A.V. Hudzevych, M.V. Dytchak, G.S. Khaietskyi, I.V. Kravtsova, Yu.V. Yatsentiuk and others.

The research of the connections between the individual components of the landscapes and within the certain regions of the Azov sea-coast has been investigated by G.G. Matyshov (2010), S.V. Hryshko (2017), V.O. Demchenko and the co-authors (Demchenko, 2015).

The analysis of the modern publications has shown that most scientific researches direct to the management of the nature use and the resources in the coastal zone (Hildebrand, 1992; Kooiman, 2008), which are closely related to the manifestation of the natural processes of the interaction and their anthropogenic modifications. It emphasizes on the complexity of the observation of the natural component of the interaction between the dry land and the sea and the importance of taking it into account (Schlüter, 2020). It is also difficult to detect the interdependencies between the social and the ecological systems, between the subjects and the managerial risks. At the same time, many scientists (Pittman, 2016) determine that the integration between the theories of the research of the dry land and the sea is still too weak. The main difficulty is that at present the structure of the observations of the processes in the dry land and in the sea is different and it does not help to the integration of these researches. In addition, in the interaction of the dry land and the sea has been detected high variability and the contradictions of the natural boundaries, which emphasizes more the aspect of the interdependence between the dry land and the sea through the shoreline. These boundaries are difficult to detect due to the variability in the natural, the ecological and the social environment.

It is clear to the scientists that if you want to use the coastal theory of the management, it should be understood the peculiarities of the coastal zone through the physico-chemical interactions between the dry land and the sea and their intensity. However, it can help in the development of the effective structure of the management which can provide not only the quality of the environment, but also its stableness.

The purpose of the article is to reveal the peculiarities of the coastal zone of the sea as a part of the integral landscape space, which are caused with the manifestation of the para-dynamics on the border of the contrasting environments.

The material and the methods of the research. The methodical basis of the article has been the number of the methods and the rules formed in the modern landscape science, the landscape ecology and the coastal science. The main research methods have been: the analysis and the synthesis of the empirical data, the method of the analogies, the field researches, the cartographic, the leading factor, the conjugate analysis of the components, the remote research, the method of the scientific generalization.

The use of the method of the analysis and the synthesis of the empirical data is associated with the significant scattering of the geophysical and the geochemical data, which confirm the existence of the interaction. Therefore, the collection of the diversified data, their machining and the interpretation have become the important component of the research. The method of the analogies has given the possibility to compare the types and the nature of the interaction in the different areas of the coastal zone, to detect the reasons of the differences. The field researches are applied for the specification of the available

cartographic information and the results of the decipherment of the satellite images of the studied surface. The method of the leading factor is applied for the detection from the significant diversity of the para-dynamic interactions of the main, which determines the course of the processes and their results. The conjugate analysis of the components has given the possibility to reveal the dependences of some processes on others, and also to detect the appropriateness in the chain of the "process-result". The remote research has been mainly related to the explorations of the dynamics of the shores, the changes of their configuration in the space and the time, and also in the identification of the places of the separation along the coastal drifts of the deposits. The method of the scientific generalization is applied for the final stages of the research and during the formulation of the conclusions.

The results and their analysis. In the coastal zone of the seas and the Sea of Azov in particular, the landscapes are formed that, at first sight, are similar to other landscapes of the dry land, but this is not entirely true. Here the number of the natural processes is arisen and the factors are appeared, caused the interaction of the water surface and the adjoining dry land which modify the individual properties and the components of the landscapes. It includes the microclimatic, the geophysical and the geochemical interactions, the coastal abrasion and the accumulation of the sediments, the infiltration of the seawater in the reduced areas of the dry land, the salt metabolism, the migration of the living organisms and many others. Within the coastal zone, the consequence of the interaction of the contrasting environments is the significant increase of the biotope and the landscape diversity, accompanied with the appropriate increase of the bio-productivity.

Together with it, in the coastal zone, the favorable conditions for the development of the maritime types of the anthropogenic activities have been created with the nature such as the fishing, the marine transport, the recreation and the tourism, and so on. The combination of the natural and the anthropogenic factors of the development of the maritime areas makes the latter as one of the most diverse and the valuable in the ecological, the social and the economic relations of the area of the landscape space.

The "Para-dynamic" (para-genetic) interactions between the contrasting environments, for the first time, have called and have introduced into the scientific circulation in geography by F.M. Milkov (1966), and the awareness of the priority of the consideration of the process component during the separation of the landscape systems has led in 1977 F.M. Milkov to the formulation of the idea of the existence of the para-dynamic landscape complexes and the necessity of their research within the new perspective direction of the landscape science (Milkov, 1981).

This name is caused with the fact that "para" means "near", and "dynamic" is the movement, the interaction. So, it is a phenomenon caused with one or more processes. Thus, in the maritime zones, this movement is caused with the interaction between the contrasting environments such as the part of the marine water surface and the part of the dry land which is adjacent to the contact shoreline.

The coastal marine zone has been determined with the resolution of the World Conference on the Coastal Zones (1993) as the specific geographical space, which is characterized with the concentration of the coastal environments and the appropriate natural and the anthropogenic systems which are close contacted. In the widest understanding of this term, the coastal marine zone is a part of the dry land which depends on the close location to the sea and it affects the sea, and also that part of the sea that feels proximity of the dry land. It is characterized with the originality of the geological, of the geographical, of the meteorological, of the energetic, of the physicochemical, of the biological phenomena and the processes and it generates the unique style of the coastal economic activity of the human (Pittman J, 2016).

So, the coastal zone of the sea we mean as the zone of the mutual influence of the territory and the water surface, the peculiarities of which are determined with the processes of their interaction such as the geomorphological, the microclimatic, the process, the migration. It stretches along the contact shoreline. Most often, this interaction is determined geomorphologically (Zenkovych, 1980), with the result of the manifestation in the form of the beach. The manifestation of the microclimatic, the process and the migratory interactions in the coastal zone of the sea is also distinguished with its specifics through the migration of the ions, the salt and their solutions, the manifestation of the breeze circulation, the humidity of the air, etc.

Acting in the coastal zone of the sea the processes and the forces, the forms of the relief, the nature of the deposits, the bioproductivity and the biodiversity, the forms of the economic use of the shore are so peculiar (Dergachev, 1987, Vedeld, 1994) that its secretion into the separate natural-economic object is not only undoubted, but it is also quite necessary. The main peculiarities of their functioning is the high variability and the dynamics of the litomas, associated with the increase and the decrease of the level of the water activities of the seawater. As a result, there is a rapid

reforming of the coastal relief and its variability in the space and the time. The movement of the coastal-marine sediments along the isobaths of the coastal slope is a common phenomenon for the maritime coastal zones, which cannot physically occur directly on the dry land. Besides, the migration of the soil solutions in the coastal zone is more intense compared to the dry land, which causes the slow formation of the soil cover. The biological productivity of the coastal zone of the sea is also more high for the adjacent dry land or the deep of the surface water: here the manifestation of the "biological effect" is taken place such as the highest biological productivity and the concentration of the biological diversity of the plants and the animals due to the intensive metabolism of the substance and the energy.

In the coastal zone of the sea there are overall phenomena of the para-dynamics such as the material, the energetic and the informative. Here the system of the contacts between the dry land and water is extremely complex. This is due to the significant concentration within it of the multidirectional material-energetic flows and the transfers as both longitudinal and the transverse (Vorovka, 2013; 2018). The last are caused with many factors: the microclimatic differentiation, the complex configuration of the shoreline and the peculiarities of its spatial orientation, the predominance of the wind currents of the certain direction and their strength, the presence of the mouths system of the river, the character of the circulation of the water masses, the peculiarities of the relief of the dry land and the seabed and others. The consequence of such contact is diversity formations such as from the peculiarities of the relief to the increased concentrations and the totality of the living organisms.

At the same time, the significant number of the anthropogenic objects are concentrated within the coastal zone of the sea, which form their own system of the para-dynamic connections. The existing and rather complex structure of the natural connections is more complicated with the para-dynamic connections of the anthropogenic origin, which unite the components due to the manifestation of the appropriateness of the anthropogenic (social) objects. In fact, the coastal zone of the sea has become as the natural-economic complex, formed with the diversity of the environments, the conditions and the resources (Dergachev, 1987).

The natural, the natural-anthropogenic and the anthropogenic para-dynamic connections within the coastal landscape system are often manifested together and it is difficult to distinguish clearly. The natural is most often manifested in the conditionally unchanged environment. The natural-anthropogenic is the synthesis of both types of the interactions. The anthropogenic is manifested mainly between the different types of the anthropogenic landscapes. The natural complexes can disappear and can modify under the influence and the domination of the anthropogenic connections.

The closest interactions are manifested in the breakers zone. With the distance from it, the connection and, consequently, the impact weaken. The appropriate change of the properties of the environment of the coastal zone of the sea gives the right to call it as the transitional zone of the geographical space, or the geoecotone, it is with the set of the properties that is manifested within certain limits on both sides of the shoreline (Vorovka, 2018). The contrast of the environments and the presence of the close contact between the active components within the coastal marine zones cause the formation of the active surfaces (Ajzatullin, 1984), or the surfaces of the interaction, which underline the ecotonic contents of the coastal marine zones. The most active surfaces of the interaction in the coastal zone of the sea are the contact surfaces of the "water-air", of the "dry land-air", of the "water-dry land", of the "water-bottom", of the "solid substrate-biota", of the "bottom-biota", of the "water -ice", of the "river-sea ". They arise on the contact of the dry land and the water, the air and the water, the air and the dry land, the coastal pond (limans, gulfs) with the water surface of the sea, the river mouths and the water surface of the sea, the water with the seabed, the living organisms with the abiotic components of the coast, the anthropogenic objects with the natural components of the coast.

Among the peculiarities of the interaction of the contrasting environments in the coastal zone of the sea, which affect the structure and the functioning of the landscapes, the following peculiarities should be singled out (Vorovka, 2013):

- the complex spatially-temporal movements of the water, the solid and the gaseous substance in the coastal zone;
- the intensive phase transitions of the substances such as the freezing of the water, the melting of the ice, the dissolution of the salt and their crystallization from saturated solutions, the dissolution and the secretion of the gas, the saturation of the water with the oxygen during the swash;
- the intensive photo- and chemosynthesis;
- the destruction of the organic and the inorganic substances, the mineralization of the organic substances;

- the intensive migration of the organic substances and the living organisms;

- the intensive and the close interaction of the hydrosphere, the lithosphere, the atmosphere and the biosphere.

In the coastal zone of the sea, the para-dynamics is caused with the processes that are represented mainly with the hydrogenous, the gravitational, the aeolian, the flotation, the hemogenic, the biogenic, the phase and the anthropogenic groups (Fig. 1). The group of the hydrogenous is represented with the breakers migration of the sediments, the differentiation of the sediments on the seabed and the river runoff. The gravitational group is represented with the different intensity of the migration of the sediment on the different speed slopes, the coastal gravitational processes and the sedimentation of the solid and the suspended substances from the water. The group of the aeolian processes is associated with the migration of the substances between the sea and the dry land in the wind flow (the breeze circulation, the continental transfer, the sedimentation from the atmosphere). The hemogenic and biogenic processes in the para-dynamic interaction have extremely large diversity, among which the brightest are the salt and the ionic exchange, the migration of the biogenic substance, the interchange of gas, the changes of the bioproductivity, and others. The significant role in the functioning of the coastal landscapes and the aqua-landscapes is played with the phase transformations of the substances such as the evaporation and the condensation of the moisture, the crystallization of the salt and the water, the transformation of the energy, the formation and the decomposition of the organic substance, and others. The energy processes are accompanied by the inflow, the release and the storage of the energy during all the above-mentioned processes.

The most widely material-energetic flows from the dry land to the water surface of the sea are represented due to the higher hypsometric position. However, there is the specific phenomenon among the interactions of the sea and the dry land in the breakers zone such as the movement of the parts of the different sizes in the opposite directions under the influence of the surf activity: the volumetric and the coarse-grained parts of the biogenic origin (mostly the shells of the dead mollusks) move towards the shore, while small low-like abiogenic are carried out to the sea. This fact plays the main meaning for the formation of the unique features of the breakers zone of the Sea of Azov such as the presence of the sandy-shell beaches, the bars and the accumulative spits. Each of these accumulative formations is the result of the close interaction of the sea and the dry land, as the spatial appropriateness of the distribution of their granulometric compositions are evidenced.

The sorting and the bottom differentiation of the sediments as the result of the combined action of the wind waves and the gravitational processes cause the regular formation of the tiered strips of the multigrained sediments of the bottom as mainly terrigenous origin such as from the sand (fraction is 1-0.1 mm) in the zone of the swash to

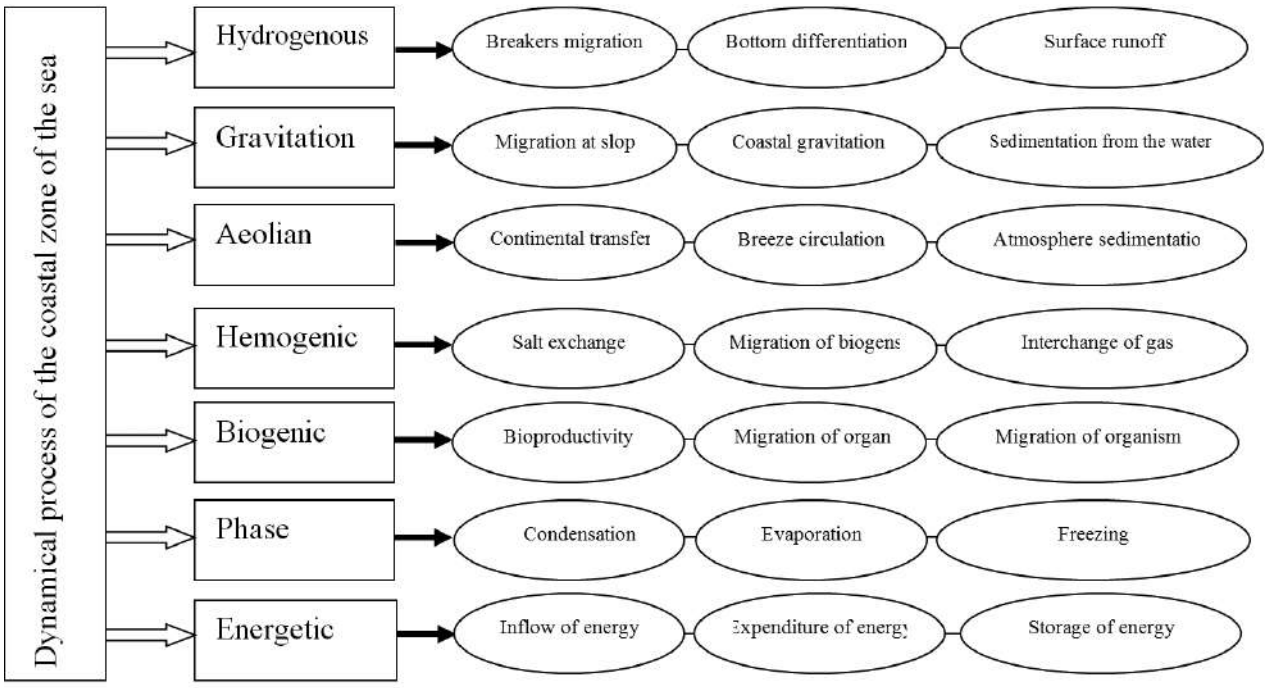

Fig. 1. Scheme of the dynamical processes in the coastal zone of the sea (Vorovka, 2018)

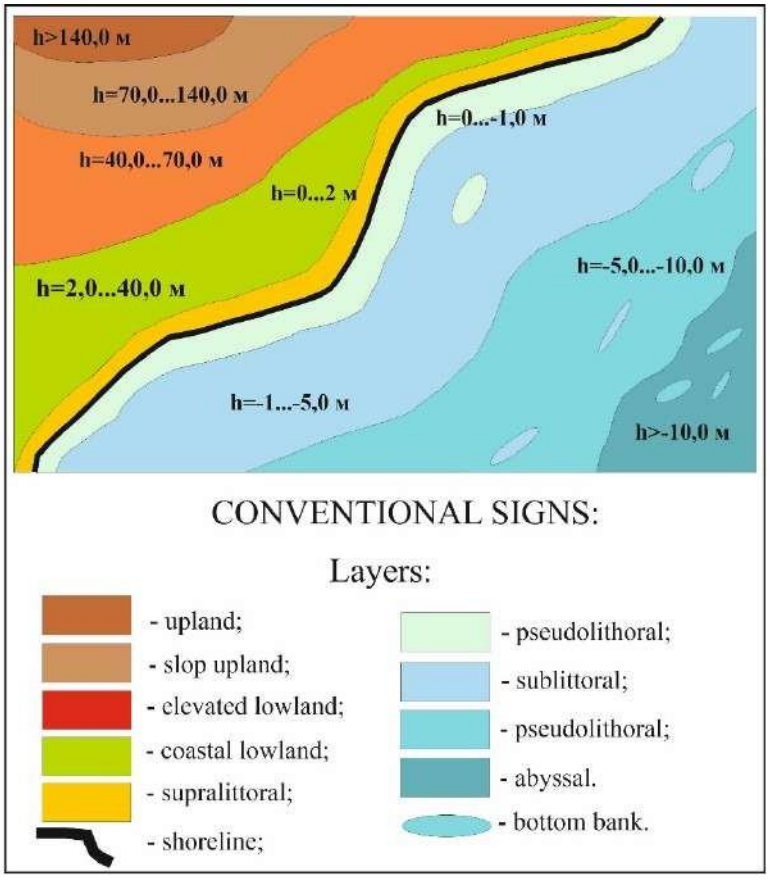

Fig. 2. Tiered structure of the coastal zone of the Sea of Azov (Vorovka, 2018)

the depth of 5-6 m, with their gradual transition to the aleurite (fraction is 0.1-0.01 mm), at the depths of 5-9 m and the pelitic (fraction is 0.01-0.001 mm) in the deep water calm areas (Fig. 2). This "striped" of the bottom is also the consequence of the para-dynamics of the dry land and the bottom with the water surface and the typical feature of the shallow and the stormy Sea of Azov. Similar layers are formed on the dry land and they are caused with the different intensities of the gravitational processes. The highest its intensity is in the coastal zone (the coastal gravitation), where the bedrock banks are destroyed under the influence of the waves, and depending on the composition of the rocks, it crumbles or it collapses. The high intensity of the gravitational processes is typical of the steep slopes of the Pryazovia crystalline massif, the sod of which crumbles and gradually slides down the slope.

The surface of the Pryazovia coastal plain is the main supplier of the terrigenous material to the bottom within the Northern Pryazovia. The dominant role of the process of the abrasion of the shores in the inflow of the terrigenous sediments is the typical feature of the sedimentation at the bottom of the Sea of Azov (Fig.2). The total value of the supply of the material of the abrasion to the seabed changes from 2.0 to 17.0 million tons with its average value until the 80's of the XX century of 6-7 million tons (Mamykina, 1980). During the period from the 90s of the XX century until today, the change of the wind circulation regime and the constant annual lift of the level of the sea by 2 mm has affected the intensity of the geomorphological processes in the coastal strip of the sea and it has caused the acceleration of the abrasion processes and the increase of the volume of the substance of the abrasion by 1.5 times, so to the size of 10-11 million tons (Matyshov, 2008). It is contributed the warming of the climate, due to which the level of the Sea of Azov is constantly rising and according to the different scenarios by 2100 year it can rise to 115 cm.

It should be noted that the high molluscous bioproductivity of the sea is also closely related to the adjacent dry land and the surface runoff from it. The hydro-carbonate class of the river runoff (Bronfman, 1985; Ivanov, 2008) of the Ca group promotes the income into the water surface of the sea of the significant amounts of the calcium, it is the main element for the construction of the shells by the mollusks. Although after the regulation of the runoff with the reservoirs and the ponds, the water of the rivers of the Azov Basin have been significantly impoverish the ions of HCO^{3-} and Ca^{2+}, and there has been some decrease of the coefficient of the carbonate, and the

terrigenous source of the income of the calcium into the water surface is still the main. Also the main thing is the terrigenous runoff of the biogenic substances (mostly the nitrogen and the phosphorus compounds), which are the basis of the bioproductivity of the Sea of Azov. If before the regulation during the period of the spring vegetation, the sea has received about 70% of the annual amount of the biogenic substances and in the modern period, it is about 45% due to their accumulation in the creation of the anthropogenic ponds during the 50-80s of the XX century.

The wind-circulation interactions are the important in the manifestation of the para-dynamic interactions in the coastal zone of the Sea of Azov. The aeolian processes are caused with both climatic peculiarities of the region and the breeze manifestations. The significant part of the bottom sediments of the Sea of Azov consists of the products of the aeolian transfer of the terrigenous origin from Kalmykia, Krasnodar territory and Rostov region, which arrive through the "wind tunnel" between Donetsk chain of the hills, Pryazovia crystalline massif and the northern offshoot of the Caucasus. Partially the aeolian material is supplied to the water surface with the west wind from the steppe zone of Kherson region and the Steppe Crimea and with the northern wind, it is from the territories of Zaporizhzhia and Dnipropetrovsk regions.

The peculiarity of the breeze relations of the dry land and the sea is due to their daily dynamics and the manifestation in the warm period of the year, starting from March. The changes of the direction of the wind during the breeze are accompanied with the special daily course of the temperature and the humidity of the air due to the advection of the warm and the moisture due to the transfer from the sea or from the shore. In the coastal zone of the seas, the breeze circulation increases the total radiation due to the increase of the line by up to 10% (Rybchenko, 2007). Due to the action of the breeze circulation on the coast, the wind speed increases from 1.5 to 4.0 m / s (it is the important for the wind energy) and the periodic changes of its direction. Another important consequence of the breeze circulation is the less frequency of the calm and more number of the days with the strong winds. The breeze circulation is accompanied with the removal of the marine ions which are saturated with the wind flow from the zone of the swash. From the maritime salted depressions, the breeze wind carries out the salt crystals both towards the sea and the deep into the dry land. This causes the significant salinity of the landscapes of the coastal zone of the sea.

The creation in the warm period of the year over the water surface of the Sea of Azov unfavorable conditions for the occurrence of the convection is accompanied with the increase of the number of the cloudless days. As a result, within the coastal zones of the sea the less number of the sedimentation is fixed compared to the other areas of the dry land, and more dry landscapes are formed. However, in the cold and the transitional periods, due to the high temperature contrast between the sea and the dry land, the fog forms here for several days in succession (Shaxnovych, 1983).

The hemogenic processes also determine the peculiarities of the maritime para-dynamic interactions and the landscapes in general, significantly affecting the course and the intensity of the interaction between the dry land and the water surface, regulating the bioproductivity, the biodiversity and the self-cleaning capacity of the geosystems. They are primarily associated with the aeolian migration and the river runoff, which cause the removal of the chemical elements (SO_4^{2-}, Ca^{2+}, Mg^{2+}) and the salt from the sea surface and the zone of the swash at the dry land and on the contrary. If mainly the chloride compounds arrive from the sea to the dry land, so mainly carbonate compounds come from dry land to the sea. With the wind currents come mainly the solid parts due to the deflation, the chemical substances as the transpiration salt, the products of the atmospheric emissions of the industrial enterprises and the motor transport (Khrustalov, 1999; Sorokina, 2006; Symov, 1989).

The hemogenic interactions between the strata of the water and the muddy sediments of the bottom form the mechanisms of the geostasis of the phosphorus and the nitrogen, which play the main role in the bioproductivity of the aqua landscapes of the Sea of Azov. Thus, the lack of the phosphorus in the strata of the marine water is compensated with its regeneration from the muddy sediments, and the surplus is with the adsorption and the supply in the bottom biogenic mud. Through the processes of the anaerobic ammonification and the nitrification in the surface sediments of the bottom, the regulation of the contents of the nitrogen in the strata is taken place.

Together with the substance in the detected interactions there is an energy-informative exchange between the dry land and the sea, which differs in its specifics. It is manifested both during the connection of the dry land with the sea (the mineral and the material composition of the terrigenous sediments, the physical and the chemical indicators of the river runoff, the biogenic runoff, the volume and the peculiarities of the pollutants, etc.) and on the

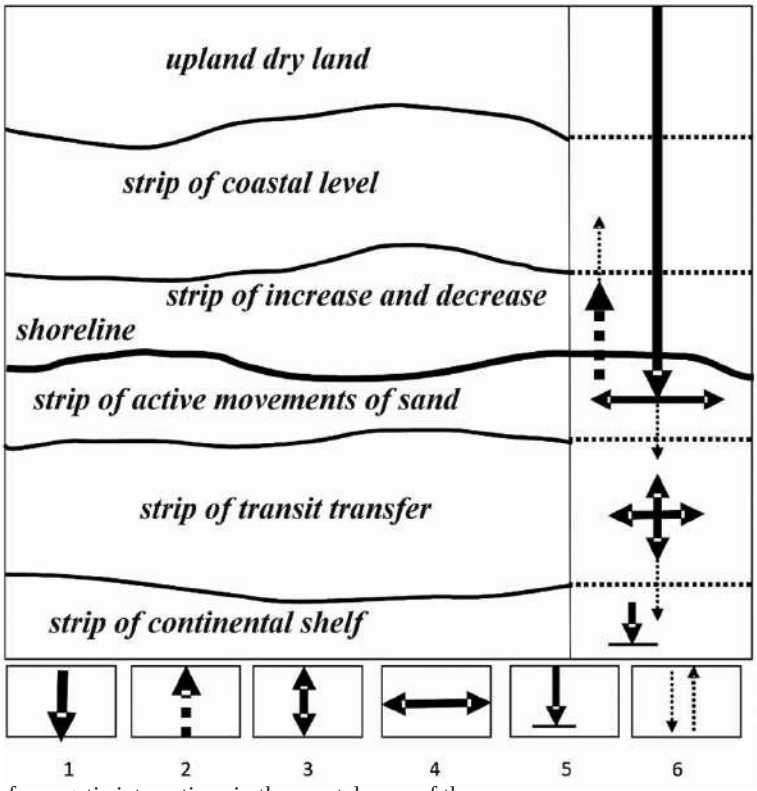

Fig. 3. Scheme of energetic interactions in the coastal zone of the sea:
1 - energetic flow from dry land; 2 - energetic flow from the water surface; 3 - transverse energetic interactions; 4 - longitudinal energetic interactions; 5 - energy storage zone; 6 - transition of energy between strips (Ortiz-Lozano, 2007).

contrary (the volume and the composition of the shell sediments of the shore, the changes of the level of the water in the coastal depressions due to the infiltration, the microclimatic indicators, etc.). The energetic flow, as the material, is directed mainly from the dry land to the sea, where it is redistributed between the strips, and also its transformation and the storage are occurred (Fig. 3). The most intensive energetic interactions are occurred in the close proximity to the shoreline. With the distance from it there is a transformation of the energy and its attenuation, and within the deep strip of the continental shelf it is its accumulation.

In fig. 4 the attempt to visualize the diversity of the para-dynamic phenomena has been done by the author which are occurred in the coastal zone of the sea. As it can be seen, it is a complex system of the interactions, as a result of which there is a material-energy-informative exchange

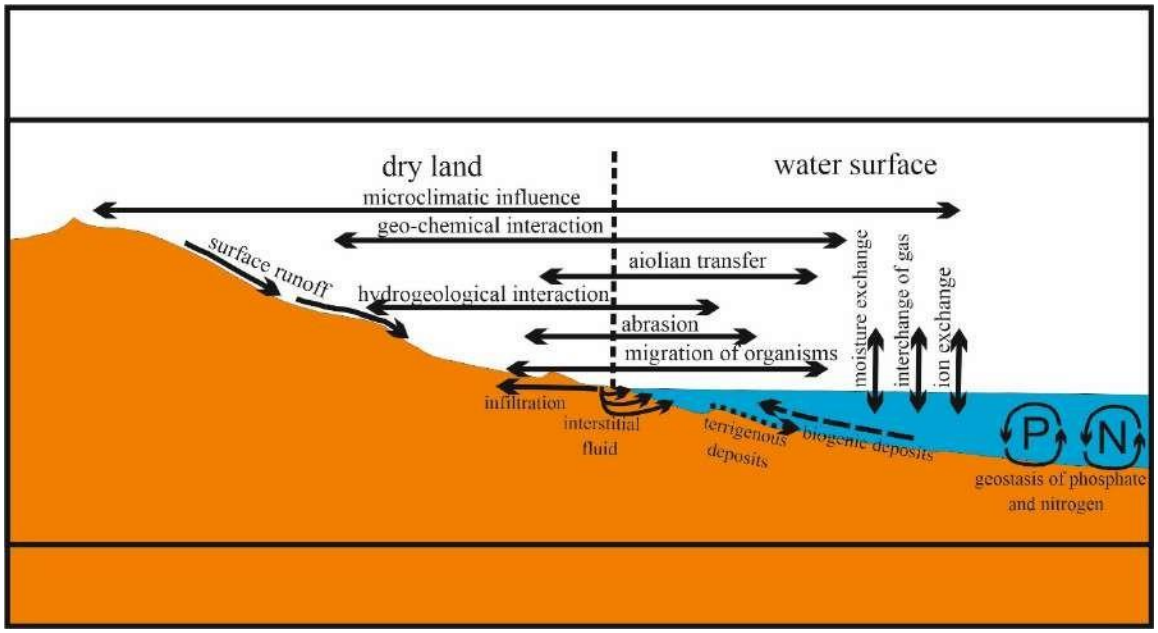

Fig. 4. Generalized scheme of interactions in the coastal zone of the Sea of Azov (Vorovka, 2018)

between the contrasting environments of the sea and the dry land. All these types of the interactions are different in the scale and the intensity, they appear in the different periods of the time, they have their own limit of the spread. Due to the high variability of these interactions, the limits of the spread of one or another phenomenon change.

Based on all diversity of the interactions, the boundaries of the coastal zone of the Ukrainian part of the Sea of Azov on the dry land and in the water surface are grounded by the author (Hryshko, 2017). Within the determined boundaries, the landscape map of the para-dynamic system has been compiled (Fig. 5). The proof of the close interaction between the dry land and the water landscapes of the coastal zone of the sea is the configuration of the boundaries, which is, in most cases, are "tied" to the contours of the coast, including the accumulative spits, the gulfs and the limans. The exceptions are the landscapes of the river valleys, the landscapes of the Pryazovia crystalline massif with its slopes and the foothill landscapes of the Crimea. Despite this, they also take the active part in the processes of the interaction which have been described above.

Conclusions. So, in the coastal zone of the sea there is the significant number and the diversity of the maritime natural and the anthropogenic para-dynamic interactions, which determine the peculiarities of the formation of the coastal landscape space. Their specifics is caused with the high intensity of the abrasion-accumulation processes; the significant dynamics of the migration of the organic and the inorganic substances; the intensive wind, the runoff and the subsoil transfer of the salt; the significant salinity of the soil horizons; the intensive longitudinal and the transverse migration of the biogenic and abiogenic substances; the peculiarities of the coastal microclimate and the wind circulation processes, including the coastal breezes; the natural-anthropogenic and the anthropogenic interactions. As a result of the manifestation of the para-dynamic interactions within the landscapes and the aqua-landscapes, the strips of the intensity of the influence are formed. With distance from the shoreline, the intensity of the interaction decreases. The intensity of the interactions determines the specifics of the structure and the peculiarities of the functioning of the coastal landscapes and the aqua-landscapes.

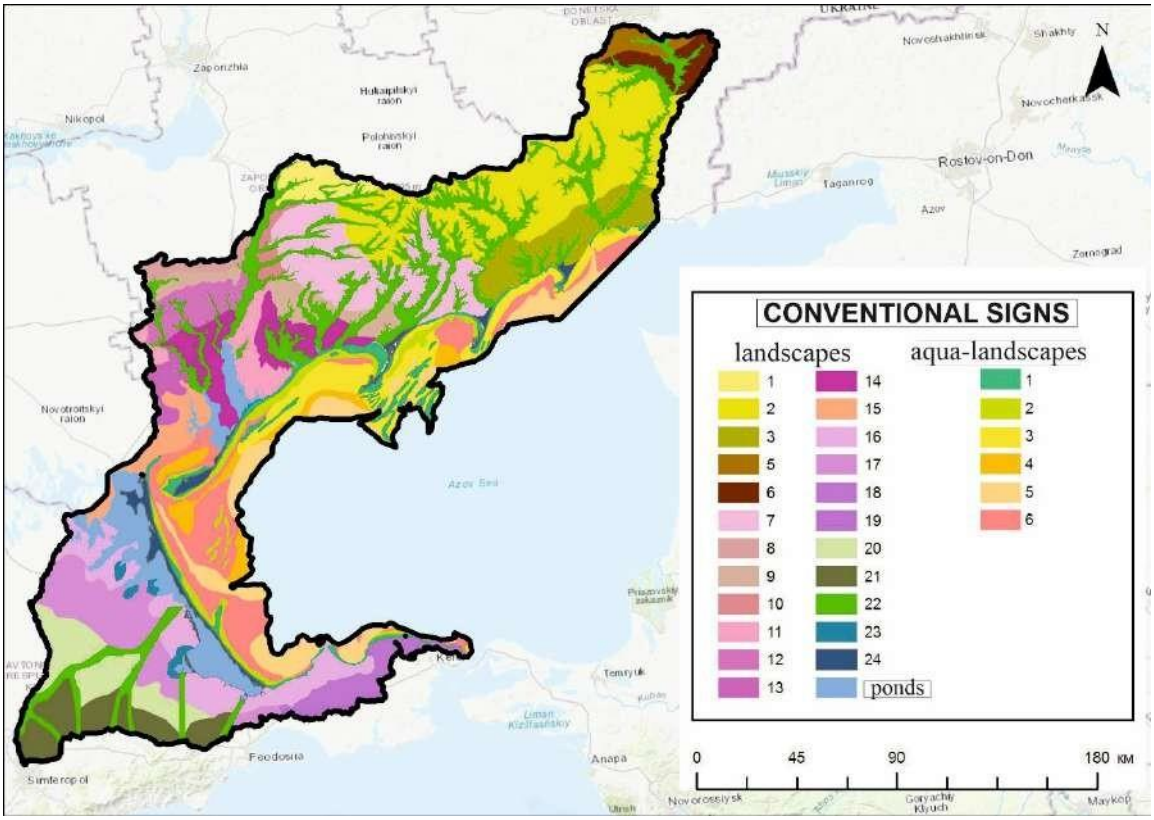

Fig. 5. Map of landscapes and aqua-landscapes of the Pryazovia para-dynamic landscape system

It is landscapes: North-steppe: 1 - loess strongly dissected slopes of the upland and the elevated plains with the anthropogenic cover on the low-power strata of Paleogene-Neogene sandy-clay deposits, which is recovered the crystalline foundation with the chernozems ordinary low-humus, with the gulches and the balks, embedded to the crystalline rock with the widespread of the agrocenosis under the forb-fescue-feather vegetation; 2 - strongly dissected upland and the hills with the

low-power anthropogenic cover in the crystalline foundation with chernozems ordinary low-humus, with the gulches and the balks, embedded in the crystalline rocks, with denudation farewell rocks (stone graves) with the widespread of the agrocenosis at the place of the forb-fescue-feather vegetation; 3 - loess weakly dissected lowland plains with the anthropogenic cover on the Neogene limestone deposits with the chernozems ordinary low-humus deep micellar under the agrocenosis at the place of the forb-fescue-feather vegetation; 5 - loess strongly dissected the upland and the hills with the Hercynian folded base, covered with the Meso-Cenozoic sediments of the various lithological composition with the chernozems ordinary low-humus, with the gulches and the balks, embedded to the carbon deposits, with the agrocenosis at the place of the forb-fescue-feather vegetation; 6 – wavy-hilly dissected structural-denudation uplands with the Hercynian folded base with the chernozems ordinary low-humus in the combination with chernozems and the sod soils on the eluvium of the dense carbonate-free rocks with the widespread of the agrocenosis at the place of the forb-fescue-feather vegetation. **Medium-steppe:** 7 - strongly dissected slopes of the loess uplands with the low-power anthropogenic cover on the Precambrian crystalline rocks, with the chernozems southern low-humus with the denudation farewell rocks (stone graves), with the gulches and the balks, embedded to the crystalline rocks, with the developed agrocenosis at the place of the fescue-feather vegetation; 8 - loess weakly drained low plains with the strong anthropogenic cover on the Neogene limestone and the sandy-clay deposits with the chernozems southern low-humus in the combination with the meadow-chernozem, the sod gley soils and the gley-solod padings with the developed agrocenosis at the place of the fescue-feather vegetation cover; 9 - loess low plains with the strong anthropogenic cover in the Neogene limestone and the sandy-clay deposits, dissected with the steppe balks, with chernozems southern low-humus, with the developed agrocenosis at the place of the fescue-feather vegetation cover; 10 - terraced loess low plains with the strong anthropogenic cover on the Neogene limestone and the sandy-clay deposits, with the chernozems southern low-humus in the complex with the solonetzic with the widespread agrocenosis at the place of the fescue-feather vegetation. **South-steppe:** 11 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits, with the chernozems southern solonetzic in the complex with dark-chestnut solonetz-like soils and in the combination with the meadow-chernozem gley soils, gley-solod padings with the widespread agrocenosis at the place of the wormwood-cereal vegetation; 12 - drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the chernozems southern weakly solonetzic in the complex with the dark-chestnut solonetz-like soils, with the widespread agrocenosis at the place of the wormwood-cereal vegetation; 13 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the dark-chestnut solonetz-like soils in the complex with the solonetzes and in the combination with the meadow solonetz-like soils and the gley-solod padings with the widespread agrocenosis at the place of on the wormwood-cereal and solonetzic vegetation; 14 - drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits, with the dark-chestnut solonetz-like soils with the widespread agrocenosis at the place of the wormwood-cereal vegetation; 15 - weakly drained lowland maritime loess plains with the anthropogenic cover on the Neogene sandy-clay deposits with the chestnut medium- and strongly solonetz-like soils in the complex with the solonetzes and in the combination with the meadow solonchaks with the widespread agrocenosis at the place of the wormwood-cereal and solonchaks vegetation. The **Crimean analogues of the steppe landscapes:** 16 - low loess plains of the edge depressions with the anthropogenic cover on the Neogene sandy-clayey rocks, with the chestnut and the dark-chestnut solonetz-like soils in the complex with the solonetz and the meadow solonchaks with the widespread agrocenosis at the place of the wormwood-cereal and solonetzic vegetation; 17 - low loess weakly dissected plains of the edge depressions with the anthropogenic cover on the Neogene sandy-clayey rocks with the chernozems southern solonetzic in the complex with the dark-chestnut solonetz-like soils and the solonchaks with the widespread agrocenosis at the place of the wormwood-cereal and solonetzic vegetation; 18 – lowland hilly wavy-bald mountain plains of the foothill depressions with the surface deposits of the dislocated Paleogene-Neogene sediments, with the chernozem and the dark-chestnut solonetz-like soils in the complex with the solonchaks on the eluvium of the shale clay, the marl and the limestone under the agrocenosis at the place of the wormwood-cereal and fescue vegetation; 19 - lowland sloping denudation plains of the foothill depressions with the surface deposits of the dislocated Paleogene-Neogene sediments, with the chernozem and the dark-chestnut solonetz-like soils in the complex with the solonetzes on the clay eluvium under the agrocenosis at the place of the wormwood-cereal and fescue vegetation; 20 - lowland weakly dissected loess plains with the anthropogenic cover on the Neogene limestone, with the chernozems southern low-humus carbonate (micellar) under the agrocenosis at the place of the wormwood-cereal and fescue vegetation; 21 – lowland weakly dissected accumulative-denudation plains with the anthropogenic cover on the Neogene limestone with the chernozems on the eluvial-deluvial carbonate deposits, under the agrocenosis at the place of the wormwood-cereal and fescue vegetation; 22 – flood-plain, meadow-steppe and the solonetzic-solochaks floodplain landscapes of the plains under the agrocenosis at the place of the meadow vegetation; 23 – maritime landscapes of the liman-marine solonhaks plains with the vegetation of the salted meadows; 24 – maritime landscapes of the shell-sand bars, the spits and the islands with the underdeveloped sod-chernozem solonetz-like soils and the solonchaks, under the rarefied vegetation of the maritime spits and the bars. **Aqua-landscapes:** 1 - coastal shallow dynamic areas (0-6 m) and bottom ridges (6-9 m) with the medium and close-grained sand (fraction is 1-0.1 mm> 70%) with the significant contents of the shells and the grouping of the mollusks Balanus and Cerastoderma; 2 - coastal dynamic (6-7 m) with the aleurite -muddy sands (it is 1-0.1 mm - 50-70%), with the moderate contents of the shells and the grouping of Cerastoderma and Balanus; 3 - medium-deep (6-8 m) with the aleurite-muddy-sandy mixed sediments and the contents of each fraction of 30-40% with the small part of the shells and the shell detritus; 4 - deep (8-10 m) with the moderate hydrogenous differentiation of the sediments and the predominance of the aleurite (fraction is 0.1-0.01> 70%) with the small part of the shells and the shell detritus with the widespread of the mollusk grouping of Abra, Cerastoderma, Balanus and with the small part of the groping of Hydrobia; 5 - deep (9-10 m) with weakly hydrogenous differentiation of the sediments and the predominance of the muddy aleurite (fraction is 0.1-0.01 mm - 50-70%) with the widespread of the grouping of Hydrobia, Abra, occasionally - Anadara; 6 - deep (9-10 m) with the balanced processes of the hydrogenous differentiation and the gravitational deposition, the dominance of the muddy sediments (fractions is <0.01 mm> 50-70%) with the admixture of the sand-aleurite fraction and the widespread of the mollusk grouping of Abra, Hydrobia.

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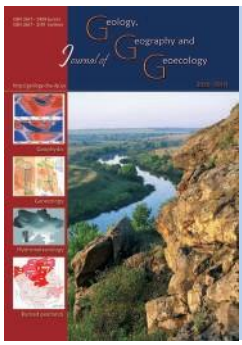

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