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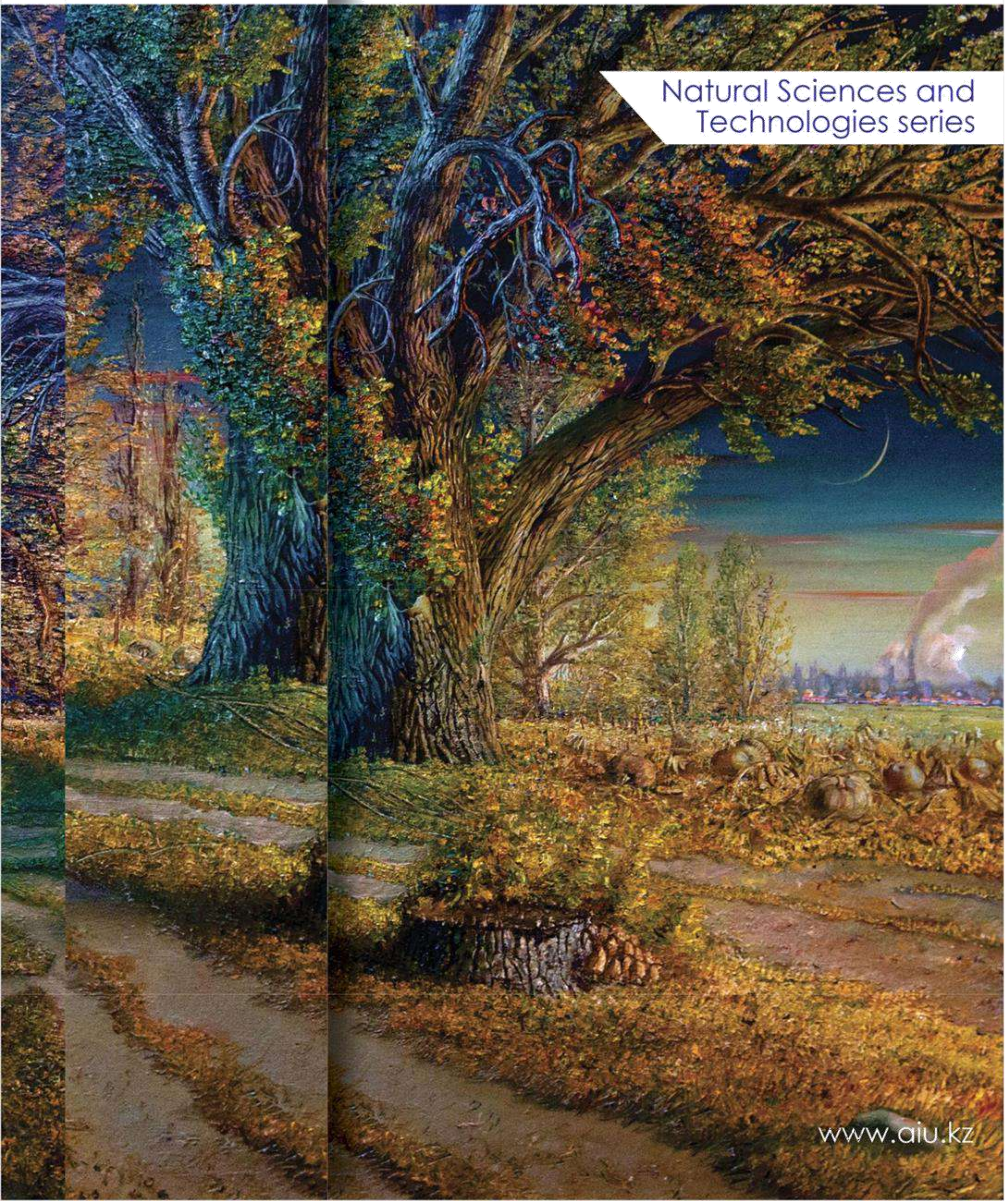

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CONTENT

Natural-resource potential of national natural parks of southeastern Kazakhstan for the development of ecological tourism

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Eco-tourism is one of the developing sectors of the tourism industry, which is based on respect for nature, the preservation of unique landscapes, biological diversity. International experience shows that the dynamic development of ecotourism takes place in specially protected areas. National parks of Kazakhstan are the most suitable for the development of ecological tourism. A network of 7parks of the desert zone as a whole located in the mountainous regions of the southeast of Kazakhstan was studied. They were created in middle and high mountain regions with a defined altitudinal zonation, which includes the steppe, forest, xerophytic-meadow, nival-subnival zones. In these parks natural monuments of national importance are located. In addition, there are 52ecological routes that introduce tourists to typical and rare landscapes, natural monuments and picturesque landscapes of untouched nature. Thus, desert national parks have a wide range of landscapes and natural resource potential for the development of ecotourism.

Keywords: ecological tourism, national natural park, tourist route, biodiversity, Kazakhstan

INTRODUCTION

Tourism and its rapidly developing new direction - ecotourism are becoming one of the most profitable sectors of the global economy, after oil production and the automotive industry. Kazakhstan has significant prerequisites and resources for the development of eco-tourism. The development of eco-tourism is promoted by the growing demand of the population of large urbanized territories to visit the ecologically clean natural environment, interest in learning new things and understanding by society of the need to preserve the diversity of nature for future generations.

International experience shows that the dynamic development of ecotourism takes place in specially protected areas. In Kazakhstan, the system of specially protected natural territories (SPNT) occupies 24.7 million hectares (8.9% of the country's area). It consists of 118 protected areas, which, depending on the purposes of creation and types of protection regime, include 10 state natural reserves, 13 state national natural parks, 2 national natural parks of local significance, 6 state natural wildlife, 5 state botanical gardens, dendrological park, 5 state protected areas, 50 state nature wildlife areas and 26 state natural monuments (Law of the Republic of Kazakhstan, 2018).

National natural parks cover an area of 1443.0 thousand hectares, out of which is 5.8% are specially protected areas of Kazakhstan (Consolidated analytical report, 2018).

This is a unique natural diversity and recreational resources of four natural zones; favorable geopolitical neighborhood with China and Russia, where there is a rapid growth of tourism; high potential for the development of eco-tourism according to the global travel and tourism competitiveness Index of the world economic forum, where in the world ranking for 2017, Kazakhstan ranked 30 out of 136 countries in terms of the number of natural world heritage sites (Travel and Tourism Competitiveness Index, 2017). The development of ecotourism is facilitated by the developed General plans for the development of the tourism infrastructure of national parks (Information on the development of ecotourism at specially protected natural sites, 2016), as well as amendments to simplify the procedures for financing activities for the development of protected areas infrastructure.

The aim of the research was to assess the development of eco-tourism within the national parks of Kazakhstan, mainly located in the desert zone. At the same time, a comprehensive assessment of the natural resource potential of national natural parks and analysis of existing ecological tourist routes was applied (Akiyanova et al., 2019).

The object of research is of great interest due to the interest in its development of scientific departments of national natural parks, local population, specialists, scientists, business structures planning the placement and development of tourist products.

Kazakhstan has significant prerequisites and resources for the development of eco-tourism. This is a unique natural diversity and recreational resources of four natural zones; favorable geopolitical neighborhood with China and Russia, where there is a rapid growth of tourism; high potential for the development of eco-tourism according to the global travel and tourism competitiveness Index of the world economic forum, where in the world ranking for 2017, Kazakhstan ranked 30 out of 136 countries in terms of the number of natural world heritage sites (Travel and Tourism Competitiveness Index, 2017). The development of ecotourism is facilitated by the developed General plans for the development of the tourism infrastructure of national parks (Information on the development of ecotourism at specially protected natural sites, 2016), as well as amendments to simplify the procedures for financing activities for the development of protected areas infrastructure.

MATERIALS AND METHODS

The initial data for the study of national parks of southeastern Kazakhstan were: published data, statistical information, digital satellite images, thematic maps, data from field research of the authors. Universal methods of scientific knowledge, including decoding satellite images, creating maps and diagrams using the ArcGIS 10.6 program, were used to assess the possibilities of developing ecotourism.

A comprehensive assessment of the network of national parks in Kazakhstan included an analysis of their spatial relevance to the latitudinal zoning and high-altitude zone of the territory, the uniqueness of natural conditions and biodiversity, the features of population settlement, and the availability of infrastructure necessary for the development of ecotourism. Analysis and mapping Assessment of the current state and prospects for the development of eco-tourism within national parks is considered with the account of their natural and climatic features, as well as the socio-economic conditions of the surrounding administrative-territorial units of Kazakhstan.

RESULTS AND DISCUSSION

In accordance with the Law on protected areas (Law of the Republic of Kazakhstan, 2018), national natural parks of Kazakhstan are designed to preserve biological and landscape diversity, use unique natural complexes and objects for environmental protection, environmental education, scientific, tourist and recreational purposes. National natural parks of the Ile-Alatau and Altyn-Yemel desert zone were opened in 1996-98, the others were opened after 2000. The main characteristics of the national natural parks of the steppe, semi-desert and desert zones of southeastern Kazakhstan are given in table 1. The analysis shows that the natural landscapes characteristic of the desert zone are partially represented in national parks and mainly in the lower tier.

National natural parks of southeastern Kazakhstan are created in areas with mainly mountainous terrain with a characteristically vertical belt. The location of national parks and their high-altitude zones has been refined using digital terrain models based on Sentinel satellite images (figure 1). The analysis showed that the landscape and biological diversity of national parks are more dependent on the vertical belt and their climatic differentiation, the dismemberment of the terrain and exposures of slopes, the lithology of rocks, the structure and composition of the soil and vegetation cover.

The current state and the possibility of developing ecological tourism within the national parks of southeastern Kazakhstan are considered in accordance with the natural and climatic zoning, the uniqueness of the geological and geomorphological structure and biodiversity.

Natural and climatic features of national parks desert zone of Kazakhstan for the development of ecological tourism

Mostly in the desert zone of Kazakhstan, spatially between 40^0 and 48^0 North latitude and 69^0 and 86^0 East longitude, there are national parks SayramUgam, Ile-Alatau, Kolsaykolderi, AltynYemel, ZhongarAlatau and Tarbagatai. They are confined to the mountain ranges of southern and South-Eastern Kazakhstan. National parks of the desert zone are located at absolute levels from 347 to 4567 meters. Depending on the absolute heights within their borders, there are two to seven high-altitude zones ranging, from desert, semi-desert, steppe and forest-steppe (represented in all national parks of the desert zone), to forest, xerophytic-meadow, tundra and nival zones. The

TABLE 1. Table 1. Main characteristics of the state national natural parks of southeastern Kazakhstan

Title	Square, ha th.	Relief (mostly)	Absolute height, m	Natural zones, subzones	High-altitude zones	Number of species of higher plants	Number of verteb rate species	Number of red listed (L)/ endemic (E)/ /rare (R) species flora	fauna
Sharyn	127,05	flat	554-1778	desert/ semidesert	desert, semi-desert, steppe, forest-steppe	1000	150	L and E50	L3
Tarba gatai	143,55	mounta nious	347-2981	semidesert	desert, steppe, forest- steppe	1600	400	E3	L40
Sairam-Ugam	149,04	mounta nious	918-3954	desert	steppe, forest-steppe	1635	371	L62	L38
Kolsai-Kolderi	161,05	mounta nious	1399-4438	desert	steppe, forest-steppe-forest-xerophytic meadows	700	231	L5	L11
Ile-Alatau	198,67	mounta nious	994-4433	desert	steppe, forest xerophytic meadow-nival-subnival belt	1000	443	L36	L20 /R2
Altyn-Yemel	307,65	mounta nious	473–4433	desert	desert-steppe, meadow-steppe	1800	393	L21 /60	L31
Zhongar-Alatau	356,02	mounta nious	892–4567	desert	steppe— forest-steppe, forest-xerophytic-meadow-nival-subnival	2168	300	L12 /E76	L12

natural features of these parks include the presence of a dense river network and in some parks – flowing lakes or lake systems of predominantly tectonic origin.

Spatially between 43^0 and 43^040 'North latitude and $78^030'$ and $79^020'$ East longitude, the state national natural Park "Sharyn" is located, which differs from the above mentioned parks. It is located within the mountain and foothill territories that pass into the inter-mountain plain. The valley of the Sharyn river is deeply embedded in the sedimentary deposits of the reservoir plain with the creation of picturesque canyons with steep, fancifully dissected slopes.

The following is a description of the most characteristic natural and climatic conditions and features of the national parks of of southeastern Kazakhstan, which contribute to the development of ecological tourism in them.

The Sharyn state national natural park is located in the South-East of Kazakhstan, 200 km East of Almaty, in the center of the Iley intermountain depression. It was created in order to preserve the unique geological and geomorphological, preserve and restore the relict floristic complexes of the Sharyn river valley.

The length of the Sharyn river canyon is 154 km, height of vertical walls varies from 150 to 300 m, width - 80 m. Deposits exposed in steep walls of the canyon, according to scientists, were formed about 30 million years ago. Thanks to a rare combination of a number of geological factors, the location of bones of the oldest representatives of fauna has been preserved in the Sharyn canyon. Scientists have found clusters of fossilized bones of mastodons, elephants, rhinos, Stenon horses, hyenas, and identified original floral pollen complexes.

The climate is continental and desert. The average annual air temperature is about 5C, the coldest month (January) is 6C, the warmest month (July) is + 27C. Duration of the frost-free period is 180 days, and the atmospheric drought is about 40 days. The snow cover is shallow (10-20 cm), lasts about 60 days, is established in December, and is destroyed at the end of February. The total amount of precipitation is about 150 mm per year. Soils from steppe (black soil, chestnut) to desert (brown, gray-brown, extremely arid) types. Among the intrazonal soils, forest-meadow floodplain and extremely arid soils of the Central Asian type are distinguished.

The Sharyn river is a major left-bank tributary of the Ile river. Sharyn is a rock type river, its' origins are located

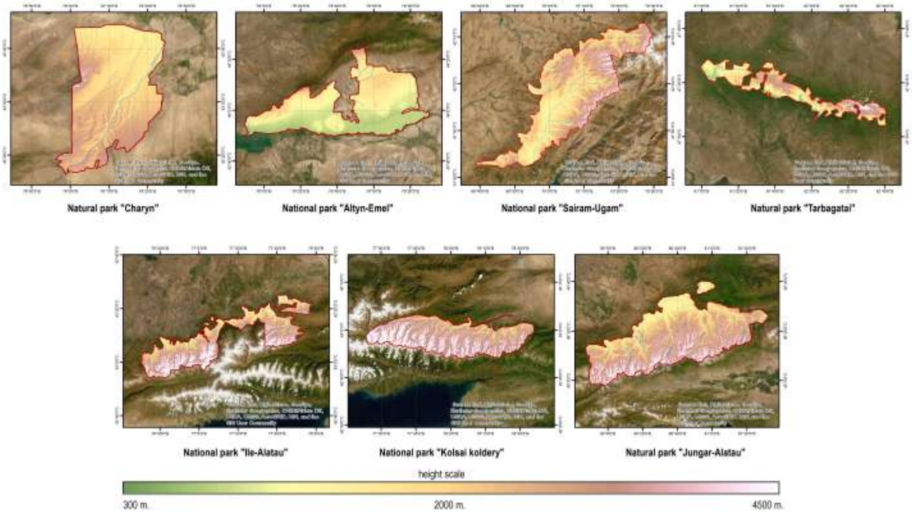

FIGURE 1. Digital terrain models of national natural parks of southeastern Kazakhstan.

above the snow line on the southern slope of the Ketmen ridge. The river crosses all vertical belts and descends from the mountains in torrents, there are picturesque rapids and waterfalls. In the foothills for a long period of time, the river cut through not only the sediments of the Mesozoic-Cenozoic, but also powerful layers of ancient rock. Here, the river formed a completely unique "Sharyn canyon" - the main attraction of the national natural park.

The flora of the national park includes 940 species of higher plants, which is comparable to the richness of the flora of individual mountain areas. The flora includes more than 60 endemic and rare species that belong to 20 families and 39 genera. The richness and originality of vegetation is due to the border position of the territory between the Kazakh and zhongar deserts, the influence of large mountain structures of the Northern Tien Shan, the presence of contrasting habitats and favorable conditions in the river valleys. There are seven types of vegetation (desert, steppe, shrub, forest, tugai, meadow and swamp), more than 70 formations and plant communities (A. A. Ivashchenko, 2009).

One of the main attractions of the Sharyn Park is a relict broad-leaved ash forest in the Sarytogai tract, with an area of 5 thousand hectares. It has been protected as a state monument of nature since 1964. the Dominant of this forest is one of the oldest species of modern flora – Sogdian ash (*Fraxinus sogdiana*). Ash forms a dense stand of trees, often with a sparse grass tier of blueberries, asparagus and blackberries.

Three species (Ferula of Ilia, the desert grate of Zinaida (*Eremostachys zenaidae*) and Michelson's kermek (*Limonium michelsonii Lincz.*) are endemic. There are 8 highly endemic species, three of them (*Oxytropis Niedzwiecki, Ferula syugatinskaya, rocky solonechnik*) are rare and listed in the Red book of Kazakhstan. There are two rare representatives of monotypic genus ikonnikovia Kaufmana (*Ikonnikovia kaufmanniana*) and plagiobasis cornflower are of particular interest. There are 21 red-book species in total (A. A. Ivashchenko, 2009).

The wildlife of the Sharyn national park is also rich. It is home to 36 species of mammals, including fox, korsak, weasel, ermine, rock marten, mountain goat, jeyran, wild boar, hare-tolai, otter, jerboa and sandwort. Of these, five species (jeyran, stone marten, marbled polecat, manul and the Central Asian river otter) are listed in the Red Book of Kazakhstan. The world of birds is diverse, with more than 200 species, including 111 nesting birds. The relict ash grove is dominated by the inhabitants of tree and shrub plantations-pigeons (wood pigeon and brown), turtledoves, orioles, southern nightingale, splyushka, warblers (hawk and zavirushka), tits (big, gray, knyazek). 18 species of reptiles. Of the lizards, the most common species are the alai gologlaz, agama, gray gecko, and of the snakes, the shield - face, patterned and multi-colored poloz. In the riparian habitats a water snake lives. The park's reservoirs are home to 10 species of fish. Seven of them are typical natives of the highland Asian fauna, and one (marinka ileyskaya) is listed in the Red Book of Kazakhstan. The black-tailed toad agama and the Central Asian frog also belong to the Red Book category. Out of the variety of insects, some species has not been studied yet, bright daytime tortoise butterfly, large tortoiseshell, admiral, apollo-mnemosyne, pale clouded yellow and large fiery hunter odorous attract the attention in summer. There are at least 10 species of red-book listed insects in the Park, including dragonflies (black-winged damselfly and emperor dragonfly), locusts (*Caereocercus fuscipennis, Saga pedo*), beetles (*European ground beetle*, musk beetle, ladybird), and others (G. M. Dzhanaleyeva, 2010). The activity of the natural park is aimed not only at preserving unique natural complexes, but also at restoring the number of

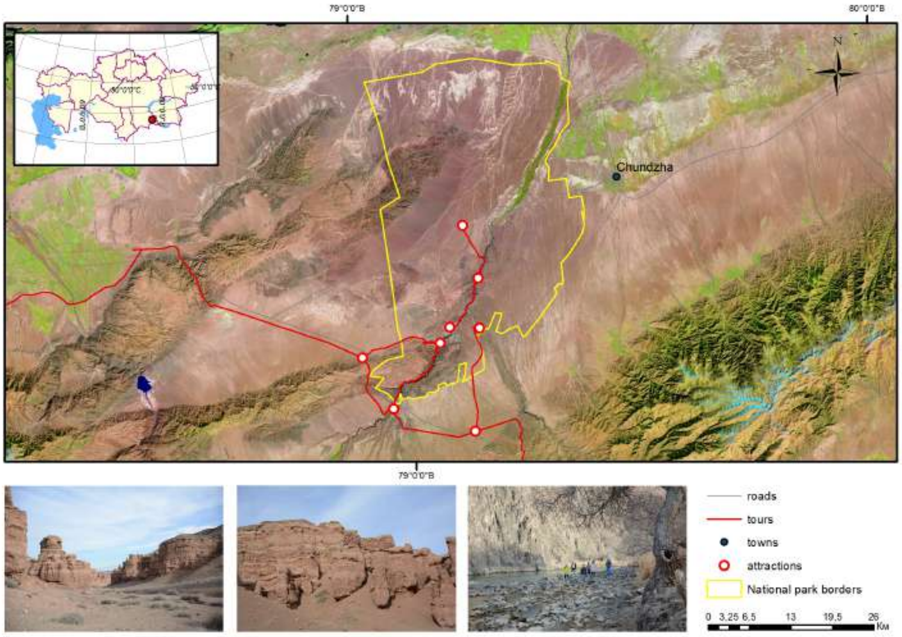

FIGURE 2. Map of the main ecological tourists‘ routes SNPP Sharyn

rare species of fauna. For example, the Aktogay tract is suitable for recreating the population of the tugai red deer (*Cervus elaphus bactrianus*), a subspecies listed in the Red books of the International Union for conservation of nature and Kazakhstan. The valley near the village of Aksai is convenient for creating a nursery for breeding rare birds-Jack (*Chlamidotis undulata*) and Saker Falcon (*Falco cherrug Grayx*) (G. M. Dzhanaleyeva, 2010).

The territory of the national park is divided into functional zones: conservation regime –9,427.5 ha (7.4%), environmental stabilization-13,147. 3 ha (10.4%), tourist and recreational activities-77,739 ha (61.2%) and limited economic activities - 26,736. 2 ha (21%) (Charyn State National Natural Park, 2008).

The territory of the national park has a high natural potential and significant recreational resources. Of particular tourists interest is the "Valley of castles" with picturesque and diverse forms of denudation, similar to quaint towers and palaces, fortress walls and majestic statues. Unique are the steep rocky ledges of the canyon, paleontological finds, rare species of flora and fauna. The canyon resembles the Grand Canyon of Colorado (USA) in miniature. In order to preserve the main attractions (Sharyn canyon and Ash grove), the national natural park was included in the UNESCO network of biosphere reserves by the decision of the International Coordinating Council of the MAB on July 25, 2018 (Two Kazakhstan reserves, 2018).

On the territory of the park there are unique historical and cultural objects, burial mounds, "Sary-Togay" burial ground (III century BC - II century BC), "Muyun-tugay" burial ground of the III century BC - I century BC.

Water and hiking trails have been developed within the national nature park. There are 3 equipped ecological tourist routes: Sharyn canyon "Valley of castles", "Sharyn ash grove", "Burial grounds and burial mounds" (figure 2). In the Sharyn canyon, there are 2 observation platforms, a descent into the canyon, wooden yurts and gazebos, etc.in the floodplain of the Sharyn river, around the "Family tree", there is a fence, wooden tables and benches are installed. In Sharyn ash grove there is a cottage and a guest house with a kitchen and dining room, a dirt road, a special check-in for buses (Charyn State National Natural Park, 2008).

The national natural park is located on the territory of three densely populated districts of Almaty region: Enbekshikazakh, Raimbek and Uyghur. The population of the territories adjacent to the protected areas as of 01.01.2019 amounted to more than 747 thousand people, 59% of the population is economically active.

The state national nature park "Ile-Alatau" was created to preserve unique mountain and foothill landscapes, flora and fauna, improve conditions for tourism and recreation, and develop and implement scientific methods for preserving natural complexes in recreational use (Ile-Alatau State National Natural Park, 2020). The length of the park from the Shamalgan river to the Turgen river is 120 km, the width reaches 30-35 km. The park is located within the low-mountain, mid-mountain and high-mountain landscapes of the Ile Alatau mountains.

The climate is differentiated by altitude climate zones. Summer is warm, winter is mild. In the foothills, the average temperature of January is -7.4^0C, July is $+23^0C$, the duration of the frost-free period is 181 days, and up to 560 mm of precipitation falls annually. The height of the snow cover in the foothills is about 30 cm, in the middle and high mountains it can reach 100 cm (Ile-Alatau).

The park occupies the Northern macro slope of the Ile Alatau mountains within absolute heights from 900 to 4540 meters above sea level (the highest point is Constitution peak, 4540 m). Several dozen more peaks exceed the four-kilometer height. The dissected mountain relief. Here you can trace a unique series of vertical zones, from the hot low-altitude semi-deserts and dry steppes below to the cool alpine meadows, tundra and nival belt with eternal snow and glaciers on the mountain tops. One of the features of the park is a system of glaciers that serves as the source of rivers. In the Left Talgar gorge, the Dmitriev glacier is located - the largest on the Northern slope of the Ile Alatau, its area is $17km^2$. The Constitution glacier is the longest (5.7 km) and one of the lowest-lying glaciers in the Park. it descends to a height of 3270 m. The Tuyyksu glacier, one of the most studied glaciers in Central Asia, is located at the source of the Kishi river in Almaty. Research has been conducted here since 1902. The river network is dense: Kaskelen, Aksai, Kargalinka, Kishi and Ulken Almaty, Talgar, Issyk, Turgen. Rivers flow in rapid streams in deep gorges, when entering the plain they lose speed, branch out, and form powerful cones of removal. The rivers are mainly snow-glacial fed with spring and summer floods. For the characteristic of the rivers are mountain torrents, for protection against which is built a system of dams and debris flow structures. The park has a large number of glacial, moraine, kar, moreno-dam and landslide-tectonic lakes. Their sizes range from 100-200 m in diameter and up to 1-1,5 km. Lakes of landslide-tectonic origin include Bolshoe Almatinskoe and Issyk lakes.

The soil cover is mainly represented by low-power gravelly soils of mountain slopes. In the middle and lower parts of the low-mountain belt, small island masses of black earth are found in places. Soils in violation of vegetation cover are easily susceptible to erosion and landslide processes.

The flora of the national park is represented by 1200 species of plants. Alpine and subalpine zones (from 2400 m to 3400 m) are characterized by bright meadow grasses, among which there are high-altitude sedge-moss swamps. Hypsometrically, juniper bushes appear below. The shrub-forest belt is located in the middle highlands at altitudes from 1600 to 2800 m. here the most typical deciduous and coniferous forests in combination with areas of grass and grass edges, lush multi-colored rose gardens. The foothills occupy a belt of 1400-1600 m and are a mountain steppe interspersed with rare groves of wild Apple, apricot, and aspen.

The special purpose of the national park is to preserve unique forest ecosystems. Here, four types of forest are classified as particularly rare, requiring special study and regular monitoring. These are moss spruce trees from Picea schrenkiana (Chinturgen massif, which is a natural monument) and "karkasniki"-natural arrays of a relict red book species- Caucasian hackberry (*Celtis caucasica Wild.*), located in the Kishi river valley of Almaty. These are apple forests – Sivers' apple tree (*Malus sieversii*), a relict species listed in the Red Book of Kazakhstan. These are apricots dominated by the common apricot (*Armeniaca vulgaris Lam.*), listed in the Red Book of Kazakhstan. Apple and apricot are wild relatives of cultivated fruit plants, the study and preservation of which is not only a national and global task. 36 species of herbaceous, shrubby and woody plants are also listed in the Red Book. Among them are the oldest forms of flowers – two types of tulips and one of iris and peony. According to experts, the tulip in the middle ages along the silk road went to Asia Minor, and from there to Holland, where it is now recognized as a national symbol (Ivashchenko et al., 2015).

The animal world of the park includes 213 species of vertebrates and more than 1,500 species of invertebrates. Of the vertebrates, there are 47 species of mammals, 148 species of birds, 8 species of reptiles, 2 species of amphibians, and 8 species of fish. Deer (maral, roe deer) live in the thicket of the forest and in open spaces, and Siberian ibex (teke) above on the rocks. Wolf, ox, boar, badger, and mouse-like rodents are frequently met. Many of the animals that live in the park are listed in the Red Book. Mammals include predatory animals (red wolf, snow leopard, manul, Central Asian lynx, Tien Shan brown bear and stone marten), ungulates (argali) and large southern rodent (Indian porcupine), and one species of fish (ili Marinka). The snow leopard is also included in the International Red Book (Ivashchenko et al., 2015). Among the birds are the sickle-billed sandpiper, falcons (saker, turf and shaheen), eagles (kumai, bearded man, Golden eagle, dwarf eagle and vulture), sparrows (painted blue tit, large lentil and blue bird), and black stork.

The territory of the national park is divided into the following functional zones: conservation regime-62,137 ha (31.2%), environmental stabilization - 16,412 ha (8.2%), tourist and recreational activities – 15,408 ha (7.6%), limited economic activities – 10,5295 ha (53%).

On the territory of the park there are famous natural monuments: "Chinturgen spruce forests", high-mountain lakes Bolshoye Almatinskoye, Bozkol, Akkol, waterfalls Kayrak and Medvezhy, majestic glaciers Tuyuksu, Dmitrieva and Constitution.

Archaeological sites of historical and cultural heritage include burial mounds of the early iron age in the Turgen gorge, Saka mounds along the banks of the river Yesik (in one of them the world-famous "Golden man" was found), as well as the medieval settlements of Talkhiz and Turgen. The Great Silk road passed through the park.

The park has exceptional conditions for eco-tourism, mass recreation and health restoration. There are 42 ecological routes for tourists, including 13 nature training trails and 29 tourist routes (figure 3).

Much is being done in the national park for the development of eco-tourism. Of the tourist routes, 21 are horse-

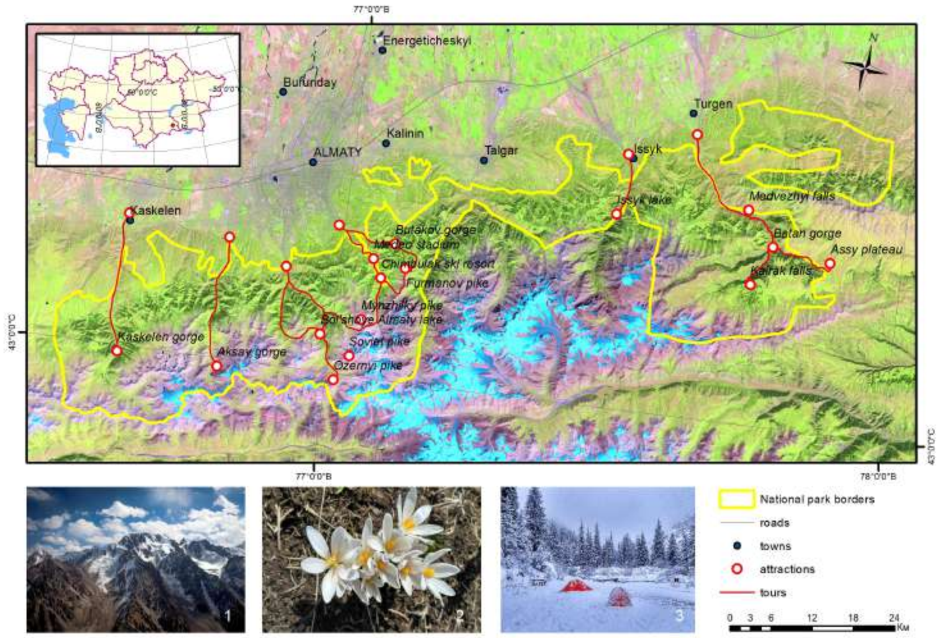

FIGURE 3. Map of the main ecological tourist routes of the Ile-Alatau SNNP.

walking and 8 are cycling routes. Developed day trips on ecological trails, multi-day trips with overnight stays in nature. Widely developed in the winter skiing, sledding and horse-drawn sleigh rides. Organized tourist groups are offered exclusive tours.

The national nature park has an open-air historical and ethnographic museum "Kieli-Bulak", an observation deck in the Maralsay gorge of the Talgar forestry, a cable road in the Kotyrbulak gorge, a stationary permanent recreation place for 300 people in the Aksai forestry and a nature Museum in the administrative building of the national park in Almaty. The national park is located on the territories of densely populated Enbekshikazakh, Karasay and Talgar districts of Almaty region. The population of the territories adjacent to the park as on 01.01.2019 was more than 768 thousand. 50% of the population is economically active.

The state national natural park "Altyn-Yemel" was created to preserve the unique ecosystems of the Ile intermountain basin, preserve biodiversity, protect geomorphological and paleontological objects, historical and cultural monuments. Ecotourism is developed within the national park in strict compliance with the norms of recreational capacity and load (Altyn Yemel State National Natural Park, 2020). The northern boundary of the national park runs along the South-Western spurs of the ridge of Altyn-Yemel, the western goes along the foothills of Sholak mountains to the floodplain of the river Ile, the easernt goes by the floodplain of the river Kokterek, the southern-along the Northern coast of Kapshagai reservoir and river silt (figure 4).

The park includes ecosystem of different altitudinal zones from the Piedmont and low desert, to lowland, mountain and Alpine steppe, above - meadow-steppe belts. The relief is represented by the Altyn-Yemel and Sholak mountain ranges, Degeres, Matai, Kalkan, Katutau and Aktau, which are the result of uplifting tectonic blocks. Deep intermountain valleys are formed by a thick layer of Neogene-Quaternary deposits.

The climate is continental, arid, characterized by summer maximum precipitation, hot dry summers and cold winters with little snow. The aridity of the territory increases from West to East. These bioclimatic features and mountain terrain determine the laws of vertical zoning of soils and landscapes (V.A. Kovshar, 2016).

In the high-altitude zone, the most common high-altitude meadow-steppe soils. Here there are two vertical zones: 1) zone of mountain xeromesophytic shrub and forb-grass, forb-steppes herbs (1700 – 2400m); 2) a zone of mountain shrub fescue-feather grass-sagebrush desert, and shrub stipe grass-fescue dry steppes (1400 - 1700 m). A distinctive feature of the park is the wide distribution of desert landscapes and soils that occupy the foothill plains and rise to the slopes of the mountains to the absolute heights of 1400-1500 m. Zonal soils are light brown.

The desert zone is located at altitudes less than 1400 meters and is divided into two subzones: 1. subzone of foothills summer sagebrush, the "Northern" deserts with brown desert soils; 2. subzone of sub-mountain perennial-halophytic and sagebrush-perennial- halophytic "real" deserts with gray-brown desert soils (V.A. Kovshar, 2016).

The flora of the national park diverse from mountain to flat desert zones and has about 1800 higher plant species, among which 21 species are listed in the Red Book of Kazakhstan, about 60 species are endemic and rare forms

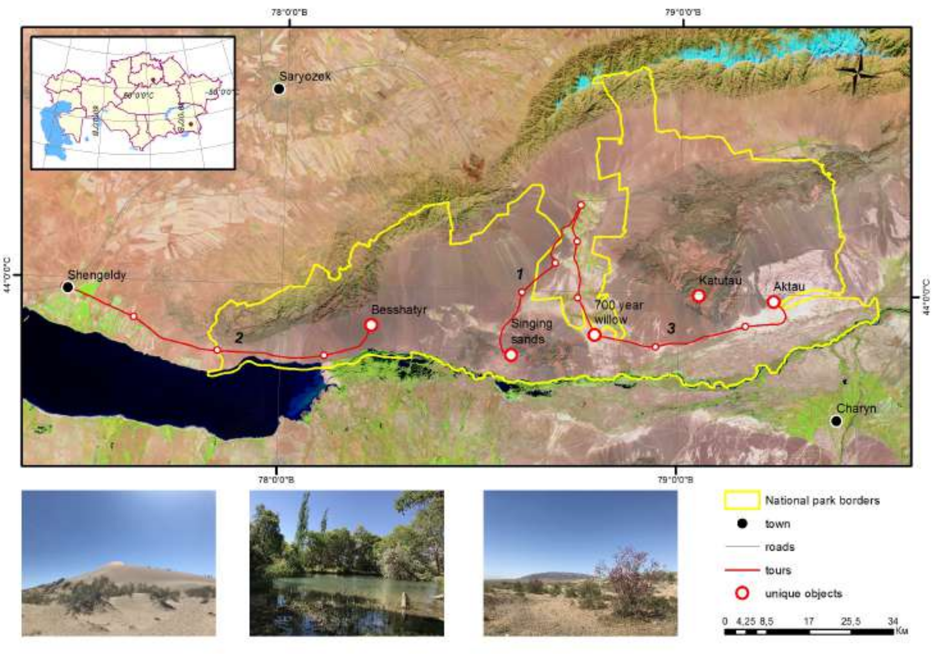

FIGURE 4. Map of the main ecological tourist routes of the Altyn-Yemel SNNP: 1) Basshi village - stone steles "Oshaktas" - Asiatic poplar grove grove-Sh.Ualikhanov spring-state natural monument "Singing barkhans"; 2) post 1-rock paintings " Tamgaly tas " - Saki mounds "Besshatyr"; 3) Basshi village - Kosbastau cordon (700 year old willow) – Katutau and Aktau mountains

within the Zhetysu Alatau and Ile-Balkash basin.

The fauna of vertebrates consists of 393 species. The park is a home to 78 species of mammals, 260 species of birds, 25 species of reptiles, 4 species of amphibians, and 26 species of fish. The animal world includes 1658 species of invertebrates. Of the animals living on the park territory, 56 species are listed in the Red Book of Kazakhstan, including 10 species of mammals (including argali, kulan, jeyran), 12 species of birds, 3-fish, 2-amphibians, 1-reptiles, and 25 species of insects. The pride of the park is a large population of kulans. In 1982, several dozen of Turkmen kulans were brought to Altyn-Yemel from the Barsakelmes reserve. Now their population numbers more than two thousand individuals. Another decoration of the national park is jeyran. In addition, in the early 2000s, as part of the reintroduction, Przewalski's horses were imported from zoos in Germany and released into the wild nature. Birds are represented by such species as: lapwing, herbalist, snipe, meadow thyrkushka, pheasant, quail, meadow arrier, yellow and black-headed wagtails, sandpiper, gull.

Altyn-Yemel is included in the UNESCO international network of biosphere reserves. The park is unique in that it preserves in its original form all kinds of natural complexes, from the unique landscape to ancient archaeological and historical monuments, as well as representatives of the richest flora and fauna.

The territory of the national park is divided into the following functional zones: the zone of conservation regime-54,767. 5 ha (20.8%), environmental stabilization – 54,590.5 ha (20.7%), tourist and recreational activities – 12,023 ha (4.6%), limited economic activities – 141,948 ha (53.9%) (The state national park "Altyn-Yemel", 2013).

Altyn-Yemel is a popular eco-tourism destination. There are 3 automobile and walking routes for tourists: 1) Basshi village - stone steles "Oshaktas" –Asiatic poplar grove-Sh. Ualikhanov spring - state natural monument "Singing barkhans"; 2) post 1-rock paintings "Tamgaly tas" - Saki mounds "Besshatyr"; 3) Basshi village-Kosbastau cordon (700 year old willow) - Katutau and Aktau mountains.

Numerous natural, cultural and historical monuments adorn the park. The Singing barkhan nature monument, 1.5 km long and up to 130 m high, emits melodious sounds in dry weather due to the friction of the smallest grains of sand when the wind blows. With strong gusts of wind, the barkhan emits a more intense and expressive sound, similar to the sound of an organ. In the Aktau mountains there is a reference stratigraphic section associated with exposures of marine multicolored deposits of the mesozoic-cenozoic period, where, bone remains of dinosaurs were found (The state national park "Altyn-Yemel", 2013).

There is the necropolis of the Saka nomadic culture Besshatyr from the VIII-III centuries BC on the distance of 3 km from the bank of the Ile river. This is a system of large mounds with a height of more than 20 meters, in which the Saka leaders who lived in the VII – III centuries BC are buried. Along the mounds there are 45 solid blocks of stone with images of animals carved on them. Tourists compare them to the famous stones of megalithic

FIGURE 5. The tract Tamgaly tas (rock paintings).

structure "Stonehenge". The park is a home to the famous monument of ancient rock images Tamgaly tas (figure 5). Petroglyphs were carved around the XVI-XIV centuries BC. These are mostly drawings of mysterious deities.

At present, the state national natural park "Altyn-Yemel" has at its disposal 6 hotels, 4 sites for placing tent camps with a capacity of 44 people at a time, as well as gazebos and viewing platforms on the territory of the park (The state national park "Altyn-Yemel", 2013).

The park is located in the Almaty region within the Kerbulak and Panfilov districts, the central office is located in the village of Basshi. The population of the territories adjacent to the protected areas as on 01.01.2019 amounted to more than 768 thousand people. About 50% of the population is economically active. The park's road network is in good condition. This generally contributes to the development of eco-tourism and the attraction of the local population.

The state national natural park "Zhongar-Alatau" was created for the purpose of preserving biodiversity (including the gene pool of globally significant wild-fruit forests) and natural mountain landscapes that have special ecological, genetic, historical and aesthetic value. Special attention is paid to the conservation and restoration of unique Apple forests – Sivers Apple trees (*Málus sievérsii*), Nezvecki Apple trees (*Malus niedzwetzkyana*), which are a source of genetic resources of world importance.

Zhongar-Alatau Park is located on the Northern slope of the Zhetysu (Zhongar) Alatau ridge, which stretches from west to east for 300 km. The climate is continental, with a long warm period and a snowy cold winter.

The park's flora includes 2,168 species of plants, of which 76 are endemic and are found only in these mountains. On the territory of the park there are rare and endangered species of plants listed in the Red Book of Kazakhstan (*Siver's apple tree, pale-flowered grouse, zhongar gentian, etc.*).

Zhetysu Alatau is one of the most saturated regions of Kazakhstan in terms of species diversity of animals, the second place in saturation belongs to Altai. The park's fauna includes 52 species of mammals, 238 species of birds, 2 species of amphibians, 8 species of reptiles, and 2 species of bony fish. Rare and endangered species include: danatinsky toad (*Bufo danatensis*), black stork, golden eagle, lammergeier, saker falcon, owl, Tien Shan brown bear, stone marten, Turkestan lynx, snow leopard, etc.

By the decision of the International Coordinating Council of the MAB on July 25, 2018, the Zhongar-Alatau SNNP is included in the UNESCO network of biosphere reserves in order to preserve the Sivers and Nedzvetsky apple trees in the wild, from which many garden varieties of apples originated.

The territory of the national park is divided into functional zones of the protected regime-142.9 thousand hectares (40.1%), environmental stabilization – 52.2 thousand hectares (14.7%), tourist and recreational activities – 81.5 thousand hectares (22.9%), limited economic activities – 79.2 thousand hectares (22.3%). It is planned to increase the protected area to 195.1 thousand hectares or 54.8% of the total area of the Park (The state national park "Zhongar-Alatau ", 2015). 7 ecological tourist routes have been developed on the territory of the park - from three-kilometer 1-day hikes to marches for 3-4 days. For the development of ecological tourism, there are natural monuments, including the Shumsky glacier, which resembles the bride's headdress "saukele", and the Upper and Lower Zhasylkol lakes. There are cultural, historical and archaeological sites: petroglyphs of the early iron age, the Obatas mound stone of the Turkic period of the VI-VIII centuries ad, the Aulie Tas ("Holy stone"), the Uygentas burial ground, etc.

The territory of the Zhongar-Alatau national park is a striking beauty of the land, which is attractive for the development of ecological tourism. The unique natural conditions of the territory, favorable climate, surface water resources, the presence of mineral springs, and the significant aesthetic appeal of the mountain landscape are complemented by the richness and diversity of the flora and fauna.

The park is rich in objects of historical and cultural heritage. Archaeological sites located on the territory of the national park date back to the early iron age, the time of formation of nomadic and semi-nomadic cattle breeding in Kazakhstan, the era of nomads. In the park is the burial ground agents, burial mounds in the river valley Sarymsakty, at the North-Western slopes of the ridge Karagach to pass Koktobe (1814 m) in the mountains of Junjurek, rock paintings in the gorge Karupsha, 7 km from the town of Sarkand, on the left bank of the river Baskan there are images of wild animals, etc. The park has exceptional conditions for organizing eco-tourism, the program of which is based on using the unique natural features of the national park in combination with visiting archaeological and cultural-historical monuments. At the same time, the park's infrastructure is poorly developed, with the exception of a network of dirt roads.

Zhongar-Alatau park is located on the territories of Aksu, Alakol and Sarkand districts of Almaty region. The population of the territories adjacent to the protected areas as of 01.01.2019 amounted to more than 146 thousand people, 77 thousand people are economically active.

The state national natural park "Sairam-Ugam" was established on January 26, 2006 (Decree of the Government of the Republic of Kazakhstan).

Sayram-Ugam park is located in the South of the country and covers the territories of three districts of the Turkestan region: Kazygurt, Tolebiy and Tulkubas. It was created through the merger of the Ugam, Tolebi and Tulkubas state institutions for the protection of forests and wildlife. The total area of the national park is 149,053 hectares. The purpose of creating a natural park was to preserve the typical and unique landscapes of the Kazakh part of the Western Tien-Shan in their natural form, use unique natural complexes and objects of the state nature reserve Fund that have special ecological, scientific, historical, cultural and recreational value for environmental, ecological and educational, scientific, tourist and recreational purposes.

The national park includes the north-eastern part of the Western Tien-Shan: the Ugam, Karzhantau and Boraldaytau mountain ranges, as well as the north-western spurs of the Talas Alatau (State National Natural Park Sairam-Ugam, 2008) (figure 6). The territory of the national park has 7 high-altitude zones, ranging from the foothill desert and mountain steppe to the high-altitude nival.

Mountain systems are neotectonic uplifts, clearly expressed in the topography. The Tulkubas section includes the Boraldaytau ridge, extending in the north-westerly direction. Here, the absolute marks vary between 1300 and 1800 meters, and the relative height above the Boraldai river reaches 300-800 meters fragments of ancient peneplain are observed. On the narrow ridge top of the Boraldaitau ridge. The slopes are steep, dissected by deep gorges. Within the Sairam-Ugam SSPE included the southern slopes of the ridge. It's the midlands, there originate of the mountain river Kairakty, Frozen, Kenosis, Kokbulak Opened Kokbulak, Nurbaiti, Zhylandy, Sisu etc.

Tolebi area of the national park includes the north-eastern mountainous part of the Ugam range. The length of the ridge is 115 km, the highest point (the Sairamsu mountain) is located at an altitude of 4,236 m. the Ridge is divided by longitudinal valleys extending from the North-East to the South-West. The predominance of steeply sloping, deeply divided terrain is characteristic. Fragments on watersheds remained aligned portions of the peneplain. One of these regions corresponds to the territory expansion of national park within Tolebi area between the headwaters of the rivers and saryaygyr Olokor (local name is Ulyzhurt) with an area of 10 000 ha.

The Ugamsky section includes the Ugamsky and Karzhantau ridges, as well as Kazygurt mountain. Individual peaks of the ridge reach 2500-2800 m of absolute heights. The highest point of the Karzhantau ridge is Mynbulak mountain with a mark of 2823 m.

Descending to the South-West, the Karzhantau ridge passes into the Karashatau hill.

North-West of the Karzhantau ridge is Kazygurt mountain with a mark of 1,768 m, which is the watershed of the Badam and Keles rivers. Kazygurt mountain is composed of Mesozoic limestones. Karst processes and forms are widely spread here: niches and small caves, a lot of springs. Paleontological finds were found near Kazygurt

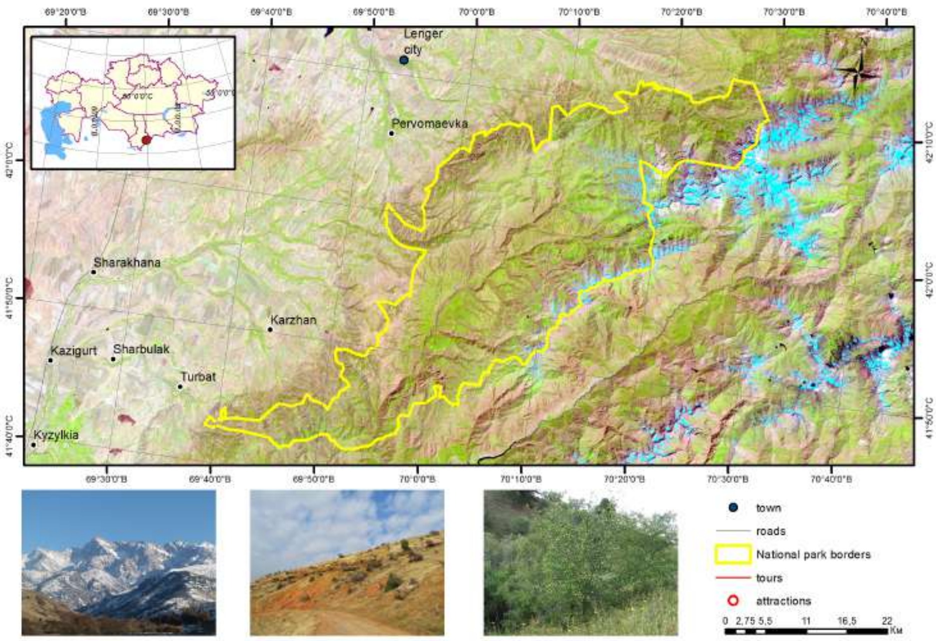

FIGURE 6. Map of the state national natural park “Sairam Ugam”.

mountain, some of them are stored in the State museum of the Republic of Kazakhstan.

The climate of the territory has continental features due to the distance from the world ocean. The winter is mild and short, with frequent thaws and a large amount of precipitation, the summer is hot, long and very dry (precipitation may not fall for 3-4 months). In the mountainous part, the continental climate is significantly weakened.

In the area under consideration, ground waters are common in quaternary sediments, and in older rocks - pressure waters separated by a regional water barrier (Eocene-Oligocene clays) with a capacity of more than 100 m. rare low - power layers and lenses of low-water-bearing fine and fine-grained Sands containing highly mineralized waters of sporadic distribution lie among the water-resistant strata. The underground waters of the region are characterized by high mineralization and variegated chemical composition, which is typical for areas of continental salinity. According to the degree of mineralization, they vary from fresh to salty.

On the territory of the national park there is a flow of a mountain stream Zhylandy, Kokbulak Cocalico, Says, Frozen, Kaskasu, Sayramsu, Ugam, Burgulyuk, Badam, etc. They are fed mainly by melted snow waters, so in the summer the flow drops sharply. Some watercourses are fed by spring water. The Ugam river is a small river, at the same time an important cross-border tributary of the Chirchik river. The length of the river reaches 70 km, the basin area is about 870 km^2. The river originates on the Ugam ridge and crosses the Sairam-Ugam SNNP.

The soil cover of the park is diverse. Mountain brown and gray-brown soils formed on eluvial-deluvial gravelly loams are common in the low-mountain region. In fine-knoll-undulating lowland area on loess-like loamy and clayey rocks developed chestnut soils. Mountain meadow-steppe and mountain-steppe soils that develop on rough eluvial-deluvial gravelly loams are common in the Western Tianshan Alpine region of Sairam-Ugam. The subalpine belt has developed mountain meadow-steppe, mountain-steppe, mountain and mountain-meadow hydromorphic subalpine soils formed on eluvial-deluvial gravelly loams. The species composition of the park's vegetation is unique. There are 240 species of plants listed in the Red Book of the Republic of Kazakhstan. Very rare species-Sogdian ash, wild grapes, Yanchevsky currant, Albert's iris-are represented by rare specimens. The most remarkable feature of the Western Tien Shan is the spread of many species of wild relatives of cultivated plants - apple, pear, plum, grape, walnut, onion and tulip.

The fauna of Sairam-Ugam park is diverse, including bears, wolves, wild boars, ROE deer, badgers, and porcupines. More rare is to meet Karatau argali, very rare are meetings with snow leopards and Turkestan lynx (State National Natural Park Sairam-Ugam, 2008).

Vegetation, wildlife, diverse terrain, rivers, waterfalls and mountain lakes create picturesque, unique landscapes that have a huge recreational potential. In the Park there are places of worship, ancient settlements and burials from various periods, but the overall cultural landscape of the Park is poorly understood and waiting to be explored. Among the high snow peaks is Sairamsky peak (4236 meters above sea level). Beautiful turquoise mountain lakes and among them the pearl of Ugam-lake Makpal (2100 m). The mountains are the "green heart" of a vast territory where more than one million people live. Mountain forests regulate river flow and enrich the air with oxygen and phytoncides. They protect the territory from rain and spring floods, slow down the melting of snow, prevent the formation of landslides and soil erosion. The mountains provide the population of Shymkent and surrounding areas with water resources and, first of all, high-quality drinking water.

In accordance with the Law on specially protected natural territories within the Sairam-Ugam SNNP, the following functional zones are allocated: conservation regime - 55589.4 ha; environmental stabilization - 13124.6 ha; tourist and recreational activities - 19711 ha; limited economic activity - 60628 ha.in Addition, the protection zone allocated in accordance with the "law on protected areas" with a width of 2 km along the border of the sspp includes 93420.4 ha. (State National Natural Park Sairam-Ugam, 2008).

On the territory of Sairam-Ugam SNNP developed and there are 10 tourist ecological route, passports are approved by order of the Committee of forestry and fauna: Horse route to the lake Makpal, the length of 45 km; Pedestrian and horse route to the lake Susingen, length 31 km; Hiking and horse trail to the petroglyphs Sazanata, a length of 12 km; Walking route to the lake "Sayramsu", length-14 km; Hiking and horse trail, "the river Saryaygyr – lake Susingen – the ampsite "South", length 72 km; Pedestrian (mountaineering) route "Boztorgay Creek", length 72 km; Pedestrian (mountaineering) route "Vladislav Peak", length 30 km; Pedestrian and equestrian route "Kaskasu-Susingen", length 32 km; pedestrian route "saryaygyr gorge", length 13 km; pedestrian route "Bird Bazaar", length 7 km (Sairam-Ugam State National Park, 2020).

The tourist resources of Sairam-Ugam park attract more and more tourists every year. However, the park does not have the necessary infrastructure and has guest houses located only in the stow Kokbulak, Tulassay, village Ugamskiy Leskhoz and the cordon in the stow Kaskasu.

Sayram-Ugam park is located on the territory of three districts of the Turkestan region (Kazygurt, Tolebiy and Tulkubas) with a traditionally high population density. The population of the territories adjacent to the protected areas as on 01.01.2019 amounted to more than 405 thousand people, 58% of which belong to the economically active population.

The state national natural park "Kolsay kolderi" was established on February 07, 2007 (Decree of the Government of the Republic of Kazakhstan). It is located on the northern slope of the Kungei Alatau range in the eastern part of the Northern Tien-Shan system. The northernmost border of the park is the Shelek river, which belongs to the lake Balkash basin. The southern border of the park is the border with the Kyrgyz Republic, which runs along the crest of the Kungei Alatau ridge. The total area of the park is 161,045 hectares. According to natural zoning, the park is included into the desert zone of the temperate zone.

The purpose of creating the park was the need to preserve the state nature reserve Fund, biological diversity, unique natural and historical-cultural complexes and objects of special ecological, recreational and scientific value. One of the most unique natural objects of the park is Kolsay lakes and Kaindy lake. Kolsay lakes are located at altitudes of 1800, 2250 and 2700 meters above sea level. They are surrounded by a unique mountain landscape, within which three high-altitude zones change and there is a variety of rare plants and animals. The Kolsay river originates in the Kungei-Alatau range and flows through three lakes: Upper, Mynzhilki, and Lower. The water in the lakes is fresh, hard, and contains sodium sulfate. The lakes are deep, the deepest place on the first lake reaches 80 m, on the second-about 50 m. The bottom is flat in places, without rocky ledges.

Lake Kaindy is one of the mysterious lakes of the foothills. It is located 12 km East of the first Kolsay lake at an altitude of 2000 m above sea level, among fir trees, surrounded by mountain peaks. The lake was created about 100 years ago as a result of the collapse of a huge mass of rock that blocked the gorge with a natural dam. the Lake is about 400 m long and reaches a depth of almost 30 m. on all sides, Kaindy lake is surrounded by steep ledges and scree rocky slopes. From the rocky ridge, you can enjoy picturesque views of the Saty gorge, the Shelek river valley and the Kaindy gorge.

The climate of this territory is subordinates to the vertical belt. In the mountains, heavy precipitation occurs in April-June, and least of all in December-January. The climatic conditions of the territory are favorable for tourism and recreation, which is facilitated by a comfortable temperature regime, clean air, lack of winds and extreme heat. The duration of the period with an average daily air temperature of +15 is equal to 110-120 days. In the transitional seasons of the year dominated by the sunny, humid weather with precipitation.

The flora of the national park has more than 700 species. There are plants listed in the Red Book-Kungei grasshopper (*Stipa kungeica Golosk*), Golden Adonis (*Adonis chrysocyathus*), Tian Shan Adonis (*Adonis tianschanica*), orange jaundice (*Erysimum perofskianum*), Schrenka fir tree (*Pícea schrenkiána*) and others. Tan-Shan fir tree forests occupy mainly the Northern slopes. The coniferous forest belt reaches up to 2700-3000 meters, gradually turning into high-altitude Alpine meadows. The Tien Shan spruce reaches a height of 40-50 meters and a diameter of 2 meters (National Park "Kolsai Lakes", 2020).

The wildlife of the natural park is rich and diverse-there are more than 200 species of vertebrates. It is home to 4 species of fish, 2 species of amphibians, 197 species of birds and 29 species of mammals. Typical inhabitants of all three natural zones are: bear (*Ursus*), wolf (*Canis*), lynx (*Lynx*), hare (*Lepus*), Siberian goat (*Capra sibirica*), snow leopard (*Panthera uncia*), wild boar (*Sus scrofa*), badger (*Meles leucurus*). Bird species listed in the Red Book of Kazakhstan: Bluebird (*Myophonus caeruleus*), painted tit (*Leptopoecile sophiae*), Golden eagle (*Aquila chrysaetos*), lammergeier (*Gypaetus barbatus*), Saker Falcon (*Falco cherrug*), kumai (*Gyps himalayensis*). Mammals include the following species of the Red Book animals: argali (*Ovis ammon*), Tien Shan bear (*Ursus arctos isabellinus*), snow leopard (*Panthera uncia*), Turkestan lynx (*Lynx lynx isabellinus*), Central Asian otter (*Lutra lutra*) (State National Natural Park "Kolsai Lakes", 2020).

On the territory of the natural park there are important objects of historical and cultural heritage. 4 km from the village of Karabulak there are rocks with ancient rock images and symbols (petroglyphs of Tanbala tas). The confluence of Kaindy and then, on the left Bank of the Ile river, are outcrops with petroglyphs (Asilegal).

Tourist resources of the Kolsay lakes park attract more tourists every year. The closest to the Kolsay lakes is the village of Saty, where the tourist infrastructure is actively developing. You can stay in a hotel or in guest houses. Also in the village of Saty one can rent horses for a walk.

"Kolsay lakes" park is located on the territory of two districts of Almaty region: Rayymbek and Talgar with a low population density. The population of the territories adjacent to the protected areas as of 01.01.2019 there were about 105 thousand people, and 69% of them are economically active.

The state national natural park "Tarbagatai" (Tarbagatay State National Natural Park, 2020) established on June 27, 2018 (Decree of the Government of the Republic of Kazakhstan), located in the Urzhar district of the East Kazakhstan region.

The purpose of creating a natural park was to preserve the natural systems of the southern slope of the Tarbagatay range, the Karabas and Arkaly mountains, and the valleys of the Urzhar, Katynsu, and Yemel rivers. The area of the park is 143550.5 hectares.

According to the physical-geographical zoning, the park is located in the semi-desert landscape area of the temperate zone and is included into Tarbagatai physiographic province Saur-Tarbagatai physiographic region of Dzungar-Saur-Tarbagatai country.

The natural park includes the southern slope of the Western part of the Tarbagatay range (Western Tarbagatay). The Tarbagatay ridge is oriented latitudinal, divides the Zhaysan and Alakol depressions, length up to 200 km, width from 15-20 to 100 km. The highest point of the ridge is mountain Tastau with abs. mark 2992.7 m (Physical and geographical conditions of the national park, 2020).

Within the borders of the Western Tarbagatai, the mid-mountain, low-mountain and foothill adyr relief are distinguished. Sharply divided middle mountains have the highest absolute heights of 2000-2900 m. this type of terrain is characterized by the presence of deep gorges (up to 700 m). Scree is developed on the slopes of the gorges. At absolute altitudes of 2000-2200 m, there are kars -traces of ancient glaciation are noted. The foothills of tectonic ledges are adjoined by powerful foothill plumes of removal cones and the adyr relief. The adyr relief is an alternation of ridges and hummocks with a height of 50-70 m, with weakly grass covered slopes.

The Tarbagatay ridge is located in the zone of dry steppes, the total radiation per year is $120 kcal/cm^2$, the radiation regime in winter is reduced by more than 5 times compared to the summer. Here, the effect of temperature inversion extends to its very tops, so relatively warm weather is often observed.

There are rivers on the territory of the park, the largest of which are Karakol, Karabuta, Keldymurat, Urzhar and Ayagoz. The current glaciation of Tarbagatai is insignificant, there is only one hanging glacier up to 0.7 km long, located on the Northern slope of the ridge near mount Tastau (2794.7 m).

The soils of the Tarbagatai range are very diverse in accordance with the vertical belt. The following soil zones are distinguished: 3100-2400 m-dominated by mountain-meadow Alpine black soils, combined with mountain-steppe. Below, from 2400 to 1800m, the mountain-meadow subalpine black soils are developed in combination with the mountain-steppe ones. From 1800 to 1000 m, mountain-steppe xeromorphic leached soils are developed in combination with mountain black soils. Below, from 1000 to 700 m, southern granular black soils, dark chestnut and chestnut soils are developed, from 700 to 500 m - light chestnut soils.

There are 1,640 species of plants within the park, including many species of medicinal plants. The peculiarity of the park is the presence of more than 35 species of endemic plants included in the Red Book of Kazakhstan: mertensia tarbagataica (*Mertensia tarbagataica*), stelleropsis tarbagataica (*Stelleropsis tarbagataica*), acantholimon tarbagataicum (*Acantholimon tarbagataicum*). One of the aims of the park is to preserve rare species of trees and shrubs (Siver's apple (*Málus sievérsii*), Ledeburov almond (*Amygdalus*), Altai wolfberry (*Daphne altaica*), etc.) and herbaceous vegetation (pale-flowered grouse (*Fritillaria pallidiflóra*), snow weevil (*Cardamine nivalis*), needle-tailed Holly (*Oxytropis Hystrix*), ledeburiella zhabricevidnaya (*Ledeboriella seseloides*), etc.).

There are 376 species of vertebrate fauna in the Tarbagatai national park, including 19 species of fish, 23 species of reptiles, 2 species of amphibians, 272 species of birds, and 60 species of mammals. Among them, 40 species of animals are included in the Red Book of Kazakhstan. Ecotourism on the territory of the Tarbagatai state enterprise is at the very initial stage of development. The park is located on the territory of Urzhar district of East Kazakhstan

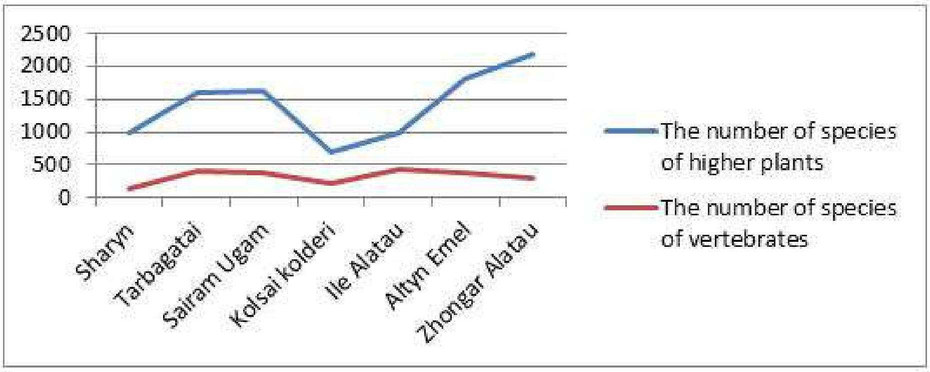

FIGURE 7. Total number of species of higher plants and vertebrates within the national natural parks of southeastern Kazakhstan

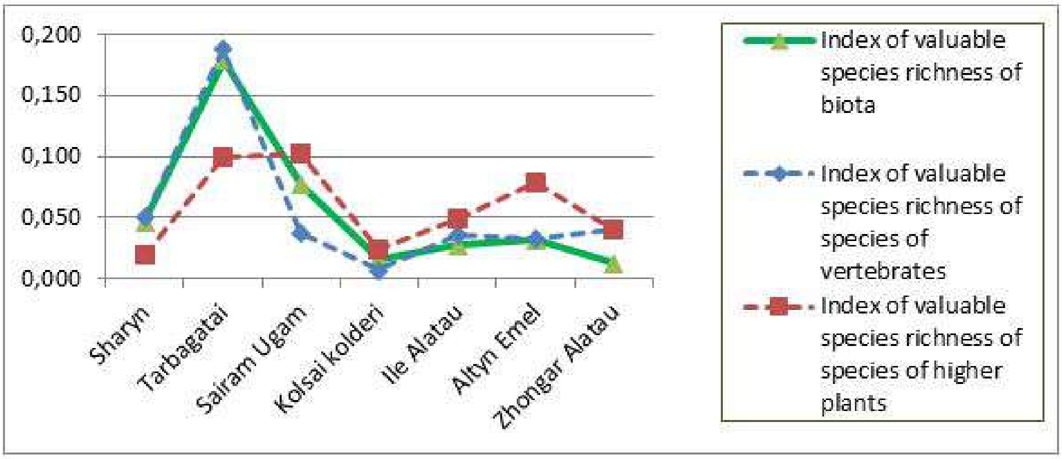

FIGURE 8. Index of valuable species richness of species of higher plants and vertebrates of national natural parks of southeastern Kazakhstan

region. Thus, the population of the territories adjacent to the protected areas as of 01.01.2019 amounted to more than 74.8 thousand people (10% less than in 2009), about half of them are economically active.

National natural parks of southeastern Kazakhstan have unique natural resources, diverse landscapes, rich floristic and faunal diversity. They represent the nature of 6 high-altitude zones, which create a solid foundation and ample opportunities for the active development of eco-tourism.

A comparative quantitative analysis of the flora and fauna of the national natural parks of the desert zone of Kazakhstan showed a greater variety of higher plants, compared with the diversity of vertebrate species. At the same time, the largest number of species of higher plants are confined to the national natural parks of Zhongar-Alatau, Altyn-Yemel, Sairam-Ugam and Tarbagatai (Fig. 7). Among them, the national natural park of ZhongarAlatau should be particularly noted, where the species diversity of vegetation reaches 2168.

The biological diversity of natural parks is characterized by the presence of rare and relict protected species listed in the Red Book of Kazakhstan. The analysis of their distribution, taking into account the area of natural parks, shows that the highest indices of valuable protected species are typical for natural parks of the mountains of the South-East of Kazakhstan: Tarbagatai, to a lesser extent Sairam Ugam and Altyn-Yemel (figure 8).

At the same time, the highest index of valuable species diversity is typical for higher plants, relative to the species richness of vertebrates.

CONCLUSIONS

Most of the natural parks of the desert zone were created in the last 20 years due to the urgent need to preserve the unique landscapes and biodiversity of Kazakhstan in the conditions of climate change and anthropogenic impact. The main purpose of their creation was to preserve and restore unique natural complexes that have special ecological, scientific, cultural and recreational value.

Natural parks of the desert, semi-desert and steppe zones located in the south and southeast of Kazakhstan within the middle and high mountainous territories with a typical high-rise zone, they are characterized by a clearly developed elevation and the differences in the exposure of the slopes. The foothills of mountain systems are located in the zone of deserts and semi-deserts, which are replaced by higher belts of steppes, forests, high-mountain tundra and nival belt with glaciers. Within the high-altitude zones, their characteristic flora and fauna is developed, rich in rare species.

These are unique natural parks, within which there are almost all existing natural landscapes in the Northern hemisphere. Natural parks "Sharyn" and “Kolsai kolderi” also represents a rare geological-geomorphological and hydrological plans the objects with relict species.

Due to the location of natural parks in the desert zone in different high-altitude zones, they have a wide range of diverse landscapes and significant resource potential for the development of eco-tourism. There are 65 routes that introduce tourists to typical and rare landscapes, natural monuments, picturesque landscapes of untouched nature, cultural and historical monuments and eco-friendly types of local crafts.

At the same time, the potential of national parks in the desert zone has not yet been fully explored. It is necessary to study aquatic ecosystems and biodiversity of water bodies, to study further rare species of biodiversity for their conservation, to establish monitoring system of natural resources and biodiversity of national parks, their adaptation to climate change, to determine the ecological and recreational capacity of national park ecosystems for sustainable development of ecological tourism.

ACKNOWLEDGEMENT

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Vulnerability of grain production of the Republic of Kazakhstan to Climate Change

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Agriculture occupies a significant share in the economy of Kazakhstan, which is based on crop production. Today, the agricultural turnover of the republic is more than 21 million hectares of land. Of these, more than 1.0 million hectares are irrigated (about 5%), i.e. agricultural crops are cultivated in conditions of natural moisturizing on 95% of the land area. Grain production is a priority in the country crop production.
The purpose of this work is to assess the vulnerability of grain production in Kazakhstan to climate change, forecast of its possible state in the conditions of climate change until 2050. To achieve this purpose, the assessment of current and expected to 2050 agro-climatic conditions, unfavorable weather phenomena for agriculture, as well as the yield of wheat and sunflower.
Climate change is known to have both positive and negative impacts on agriculture. The negative consequences include an increase in the increased frequency of droughts and reduction of agricultural crops yield [5, 9, 12, 15].

Keywords: climate change, agroclimatic conditions, heat availability, moisture availability, drought, crop yield

INTRODUCTION

Agriculture occupies a significant share in the economy of Kazakhstan, which is based on crop production. Today, the agricultural turnover of the republic is more than 21 million hectares of land. Of these, more than 1.0 million hectares are irrigated (about 5%), i.e. agricultural crops are cultivated in conditions of natural moisturizing on 95% of the land area. Grain production is a priority in the country crop production.

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Climate change is known to have both positive and negative impacts on agriculture. The negative consequences include an increase in the increased frequency of droughts and reduction of agricultural crops yield [5, 9, 12, 15].

METHODS

The article presents the results of studies obtained in the framework of the preparation of the Seventh National Communication of the Republic of Kazakhstan on climate change [12].

The study used data from the meteorological station (MS) of RSE "Kazhydromet".

For the characterization of the future climate, were used probabilistic forecasts of the average monthly air temperature and monthly precipitation amounts prepared by the expert group of climatologists of RSE "Kazhydromet". They used the combined models of the general circulation of the atmosphere and the ocean (MGCAO), prepared within the framework of the 5th phase of the CMIP5 International Comparison Project. The CMIP5 was based on the estimation of the climate of the 20th century, given in accordance with the observed concentrations of greenhouse gases and aerosols, as well as scenario estimations of the climate of the 21st century, taking into account a new group of anthropogenic emissions scenarios – Representative Concentration Pathways

(RCP) [12].

Us in the calculations was used the scenarios of air temperature and precipitation amounts for two successive 20 year periods: 2020-2039 years, with the middle in 2030 and the years 2040-2059, with a midpoint in 2050. The forecasts for two scenarios of climate change were used: RCP4.5 – climate change under the scenario of stabilization of greenhouse gas emissions; RCP8.5 – climate change under the scenario with very high level of greenhouse gas emissions [12].

In temperate latitudes, the vegetation period of most crops corresponds to the duration of the period with an average daily air temperature above 10^0C. Therefore, the thermal resources of the vegetation period were estimated by the sum of active air temperatures above 10^0C.

We have used humidification coefficient "K" to assess the crop moisture availability analogous to humidification coefficients proposed by D.A. Brinken, S.A. Sapozhnikova and Yu.I. Chirkov, L.S. Kelchevskaya [8], L.S. Kelchevskaya and Yu S. Melnik [4]. For the conditions of Kazakhstan, the accumulation coefficient of precipitation of the cold period was taken equal to 0.5, and the coefficient of air temperature – 0.12 [2]:

$$K = \frac{0.5\sum R_{11-4} + \sum R_{5-8}}{0.12\sum T_{5-8}} \quad (1)$$

where: $\sum R_{11-4}$ – precipitation amount for November–April; $\sum R_{5-8}$ – precipitation amount for May–August; $\sum T_{5-8}$ – sum of air temperatures in May–August.

At values "K" is less than 0.60, there is a deficit of moisture, at values 0.60 – 0.79 – insufficient moisture availability, at values 0.80–0.99 – sufficient, but non–sustainable moisture availability, at values 1.00–1.20 – optimal and sustainable moisture availability.

Agrometeorological phenomena that are dangerous for crops include: light frosts, droughts, dry hot winds, heavy rains and hail, strong winds and dust storms. The most widespread and dangerous in Kazakhstan are droughts and dry hot winds.

The productive reserves of moisture in the soil (PRM) serve as a direct indicator of drought. Given the rare network of PRM identification in Kazakhstan, it is very difficult to conduct a full– valuable assessment of drought based on PRM data.

Various indirect methods are used to assess drought: the hydrothermal coefficient of G.T. Selyaninov (HTC), the humidification coefficients of D.I. Shashko (Md), P.I. Koloskov, A.V. Protserov, N.N. Ivanov, L.D. Kelchevsky, D.A. Brinken, S.A. Sapozhnikova and J.I. Chirkov, the index of aridity of D.A. Ped, the agrometeorological coefficient humidifying (ACH), the Palmer Drought Severity Index (PDSI), the Standardized Precipitation Index (SPI), the Critical Water Content Index for Crops (CWCIC), the Index of Surface Moisture Reserve (ISMR) [7, 13, 14].

Long–term practice has shown that the hydrothermal coefficient of G.T. Selyaninov (HTC) for the assessment of drought in Kazakhstani conditions is the most suitable is [1, 2]:

$$HTC_{5-8} = \frac{\sum R_{5-8}}{0.1\sum t_{5-8}} \quad (2)$$

where: $\sum R_{5-8}$ – the total of precipitation over the period of May to August; $\sum t_{5-8}$ – the total of average daily air temperatures above 10 over the period of May to August.

If the HTC is 0.40–0.59, the drought is considered to be of medium intensity, less than 0.40 – strong intensity.

Also, the generalized criterion of drought is the level of decline in the yield of the main crop. Crops yield is formed under the influence of a set of factors that can be divided into two components: level of field husbandry and weather conditions [6]. Drought can be determined by calculating the share of weather in yield formation (dP, %) [1]:

$$dP = \frac{Y - Y_T}{Y_{TS}} \quad (3)$$

where: $Y-$ the average regional yields, c/ha; Y_T – trend value of crop yield, c/ha; Y_{TS} – average trend yield, over a long period, c/ha; 100 $-$ the coefficient for transfer to the interest.

If dP is minus 20 $-$ 50%, the drought is considered to be of medium intensity, more minus 50% – strong intensity.

Dry hot wind – is a complex weather phenomenon that occurs at a wind speed of more than 5 meters/second, at high air temperature above 25^0C and a low air humidity of less than 30%. As a result of the effects of dry hot wind, the plants wither and die, even if there is a sufficient supply of moisture in the soil, since the root system does not have time to supply water [8, 10].

For the conditions of Kazakhstan, E.I. Buchinsky and N.F. Samokhvalov offer the following dry hot wind criteria: air temperature above 25C, low relative humidity of air below 20%, wind speed 5 meters / second and more, and at a temperature of over 30^0C, wind speed 3 meters/second and more. According to the research by E.A. Tsuberbiller a day is considered to be dry if at noon the air humidity deficit exceeds 20 hPa (weak), 30 hPa (moderate) and 40 hPa (intense) at a wind speed of less than 8 meters/second.

RESULTS AND DISCUSSION

To assess the current agro climatic conditions and unfavorable weather phenomena for agriculture, we will take into account the heat and moisture availability of the vegetative period, drought and dry hot wind in Northern Kazakhstan (North Kazakhstan, Kostanay, Akmola and Pavlodar regions). In these regions concentrated 72% of the sown areas of Kazakhstan, 80% of grain and leguminous crops areas.

Heat availability. The duration of the vegetation period in the territory of Northern Kazakhstan is increasing from north to south from 130 to 170 days, and in the Kokshetau upland area is less than 135 days. On the territory of 4 regions of Kazakhstan, the sum of active air temperatures above 10C increases from north to south from 2100C to 3400C. In area of Kokshetau upland and Bayanaul mountains, the sum of temperatures is less than 2200C [3].

To estimate the change in thermal resources, the expected values of the sums of average daily air temperatures for May–August (T5–8) were calculated for the future climatic conditions (2030 and 2050) according to RCP4.5 and RCP8.5 scenarios, and compared with the values of the current climate (1981–2016).

Calculations have shown that the heat availability of the vegetation period in the expected climate of the 2030 years will significantly increase in comparison with the current climate. In the northern oblasts of Kazakhstan, the sum of average daily air temperatures for May–August (T5–8) will increase according to RCP4.5 scenario by 161–180, i.. by 8%, and under the scenario of RCP8.5 – by 182–205, i.. by 9%.

Heat availability of the vegetation period will increase even more by 2050. The sum of average daily air temperatures for May–August (T5–8) will increase according to RCP4.5 scenario by 265–282C, i.. by 12%, and under the scenario of RCP8.5 – by 340–355, i.. by 16%.

Thus, in conditions of further climate warming by 2050 in North Kazakhstan is expected to increase thermal resources by 12–16%, which can expand the set of cultivated heat–loving crops and will have a positive impact on their growth and development.

Moisture availability. An average of 250–400 mm of precipitation falls during the year on the territory of the 4 northern regions of Kazakhstan. From May to August (vegetatively active period), 170–201 mm of precipitation falls on the territory of North Kazakhstan region, 122–190 mm in Akmola region, 76–195 mm in Kostanay region and 129–188 mm in Pavlodar region.

The humidification coefficient "K" makes 0.8–1.2 in the territory of North Kazakhstan region, 0.8–1.2 in Akmola region, 0.3–1.0 in Kostanay region, 0.6–0.9 in Pavlodar region. To estimate the changes in moisture resources, we have calculated the expected values of annual precipitation and the amount of precipitation for the vegetatively active period (May–August), as well as the humidification coefficient (K) for future climatic conditions (2030 and 2050) under the scenarios of RCP4.5 and RCP8.5. These values were compared with the values of the current climate (1981–2016).

The sum of precipitation for the vegetatively active period according to the scenario of climate change of RCP4.5 will increase slightly by 2030 and 2050. The largest change (+ 8 percent) is expected in Kostanay region. Under the scenario RCP8.5 there are no significant changes in the amount of precipitation for May–August.

Calculation of the humidification coefficient (K) for future climatic conditions has shown that until 2050 in the northern regions moisture availability of the vegetation period will gradually deteriorate. The greatest changes are expected under the RCP8.5 climate change scenario. For example, by 2050, these changes will be in the scenario RCP45 – minus 8–12 V, and the scenario RCP85 – minus 12–17 percent.

Thus, in conditions of further climate warming until 2050, no significant changes in the amount of precipitation are expected in Northern Kazakhstan, however, the moisture availability of the vegetation period will gradually deteriorate. This is due to the increase in evaporation due to the increase in air temperature.

Expected climate change will lead to a shift in thermal zones and humidification zones to the north. Figure 1 and 2 shows the spatial distribution of the humidification coefficient K in the northern half of Kazakhstan, in the conditions of current and expected climates for 2050.

In comparison with the current climate, in 2050 K isolines will have some northward shift. "Optimum and stable moisture availability" zone (= 1,0–1,2) will completely disappear in the north of North–Kazakhstan region, and in the Kokshetau Upland area it will decrease in size.

"Sufficient but not stable moisture availability" (= 0,8–1,0) will completely disappear in Aktobe region, decrease in Kostanay, North Kazakhstan, Akmola, Karagandy, Pavlodar and East Kazakhstan regions. At the same time, this zone will almost completely disappear in the North of Pavlodar region, and in the border part of Pavlodar and Karagandy regions from the main zone will separate its small part "Korneevka–Karkaraly–Bayanauyl".

"Insufficient moisture availability" zone (= 0,6–0,8) will also move to the north in West Kazakhstan, Aktobe, Kostanay, Akmola, Karagandy, Pavlodar and East Kazakhstan regions. In the border part of Pavlodar and East Kazakhstan regions, there will appear a zone of "Moderate moisture deficit" with K humidification coefficient of = 0.5–0.6.

"Moderate moisture deficit" zone (= 0,4–0,6) will also move to the north in West Kazakhstan, Aktobe, Kostanay,

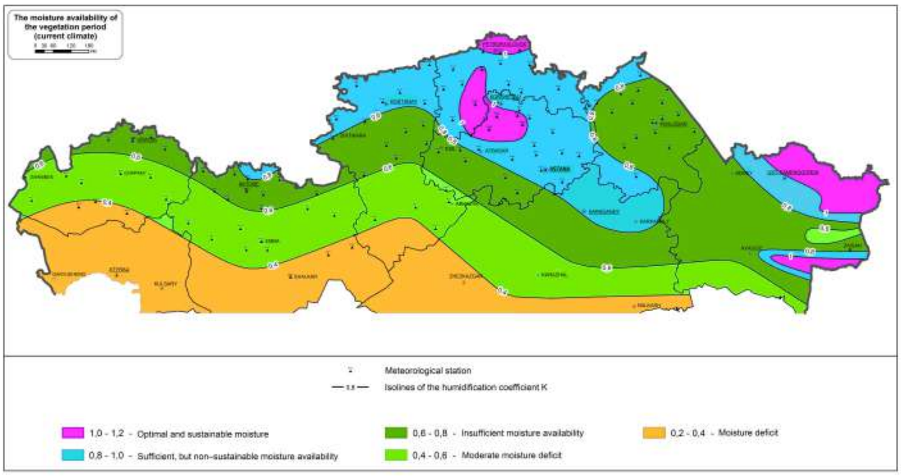

FIGURE 1. Spatial distribution of the humidification coefficient K in the Northern half of Kazakhstan in the current climate

Akmola, Karagandy and East Kazakhstan regions. This area will expand somewhat in the area of the lake Zhaysan in the East Kazakhstan region.

In the mountainous areas of East Kazakhstan region, no significant changes in moisture availability of the vegetation period are expected.

The expected shifts in moisture availability zones of the vegetation period will have a negative impact on the transitional areas of the zones, i.e. they may lead to a revision of the existing production relations. For example, changing the species or varieties of cultivated crops or increasing the proportion of livestock. Undoubtedly, it is necessary to introduce adaptation measures.

Arid phenomena. To assess the likelihood of severe droughts, HTC was calculated as per MS data for the period May–August from 1981 to 2016. The frequency of severe drought was determined as per the 36 summer series of HTC data. The probability of a severe drought was calculated on the basis of repeatability. Repeatability of severe droughts, which cause significant losses to agriculture, grows from 5% (probability of 1 every 20 years) in the north of North–Kazakhstan region to 70% (probability of 1 every 2 years) in the south of Kostanay region.

We also carried out an assessment the drought on average regional yield of spring wheat for 1966–2016, based on the calculation of the percentage of weather in the crop formation (dP).

The probability of a drought repeating in the Pavlodar and Akmola regions is approximately 1 time every 3 years, in the Kostanay and North Kazakhstan regions – 1 time every 4–5 years. At the same time, severe droughts reoccur in the North Kazakhstan region once every 50 years, in the Akmola regin – 1 time every 17 years, and in the Pavlodar and Kostanay regions – 1 time every 10 years.

In the work of L.E. Pasechniuk and V.A. Sennikov (1983) provides an agroclimatic assessment of dry hot winds in northern and western Kazakhstan [10]. According to their data, the average number of days with dry hot winds (d 20 hPa) for the period from April to October is 90–50 days in West Kazakhstan and Aktobe regions, in Kostanay, North Kazakhstan, Akmola and Pavlodar regions – 50–40 days.

Our calculations showed that dry hot winds of moderate and strong intensity, which have a significant negative impact on the growth and development of crops, occur in North Kazakhstan region for about 5 days a year. In Kostanay region from north to south, the number of days with dry hot winds increases from 5 to 70 days a year. In Akmola region, also from north to south, it increases from 5 to 25 days, and in Pavlodar region – from 5 to 20 days per year.

In the context of climate warming, the main unfavorable weather phenomenon for agriculture is drought. It is impossible to forecast drought for the long–term period. However, it is possible to estimate the expected aridity of the climate, to which all arid phenomena are closely related, including atmospheric drought and dry hot winds.

To estimate the change in the aridity of the climate, the expected values of the HTC for the vegetatively active period (May–August) were calculated for the future climatic conditions (2030 and 2050) according to RCP4.5 and

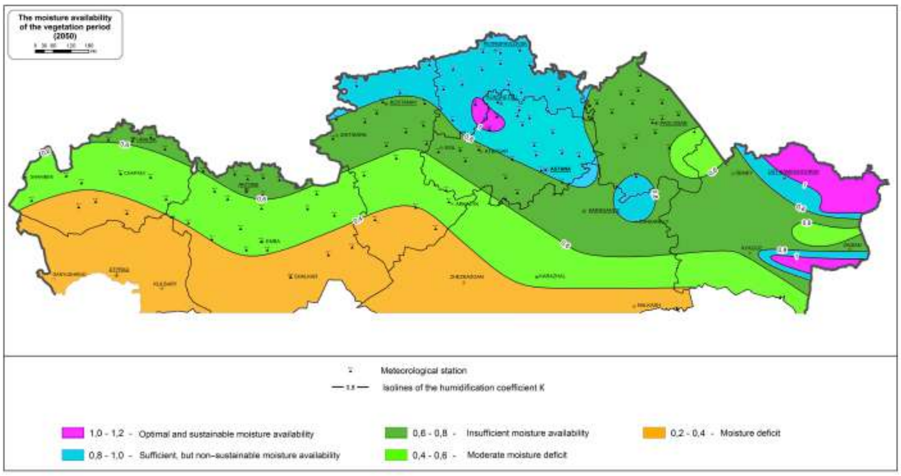

FIGURE 2. Spatial distribution of the humidification coefficient K in the Northern half of Kazakhstan in the climate of 2050

RCP8.5 scenarios, and compared with the values of the current climate (1981–2016).

Calculations of the HTC for future climatic conditions showed that by 2050 in the Northern regions is expected to gradually increase the aridity of the climate. The greatest changes of the values of the HTC are expected under the scenario of climate change RCP8.5. Thus, according to RCP4.5 scenario by 2050 these changes will be minus 7–10%, and under RCP8.5 scenario – minus 12–15%.

Thus, in the conditions of further warming of the climate until 2050 in Northern Kazakhstan, the aridity of the climate will increase, with a decrease in HTC values by 7–15%. Accordingly, the repeatability of droughts and dry hot winds will increase.

The yield of agricultural crops. Spring wheat – is the main grain and food culture. In Kazakhstan, mainly soft varieties of spring wheat are cultivated.

To study the effect of climate change on the yield of spring wheat, the yields of spring wheat were estimated for the 4 grain–growing regions in Northern Kazakhstan as per current and expected climatic conditions until 2050. The difference in their values is an indicator of vulnerability to climate change. For the forecast of yield of spring wheat was used a dynamic model of yield formation of crops [11], adapted for the conditions of the above–mentioned regions of Kazakhstan. The process of crop yield formation is a complex set of physiological processes, the intensity of which determined by the biological characteristics of plants and environmental factors. The model describes the processes of photosynthesis, respiration, growth and development of plants, as well as the influence of agrometeorological conditions on the intensity of these processes.

Current actual dates of spring wheat sowing in the northern regions of Kazakhstan fall to the third decade of May–beginning of June. According to climate change scenarios until 2050, an increase by 1.0–1.5C in air temperature is expected in June. Therefore, the yield calculations were carried out taking into account the expected earlier sowing dates: by 2030, the shift in sowing dates 4-5 days earlier than the current date, by 2050 – a shift of 8-10 days. At that used data of climate change scenarios RCP4.5, which shows a moderate change of temperature. Calculations showed that in the conditions of expected climate of 2030 the yield of spring wheat would average 63–82% of the current level (the average for 2000–2016) in the regions, and in the conditions of 2050 it would be 51–71%. This means that, while maintaining the current level of field husbandry, the yield of spring wheat will drop by 18–37% by 2030 and by 29–49% by 2050.

The main reasons for the decline in wheat yield are:

an increase in evaporation leading to a decrease in humidification of the territory, despite the expected increase in precipitation up to 10%;

an increase in air temperature above the optimal value for the growth and development of spring wheat.

If we consider that 82% of the areas under wheat are in the Northern regions, it can be argued that grain production in Kazakhstan is very vulnerable to climate change.

Under the expected conditions of 2030 and 2050, higher yields of wheat are possible with a high level of field husbandry, i.e. with the introduction of adaptation measures and cultivation technologies.

Sunflower is the main oilseed crop in our country. Sunflower is photophilic and thermophilic culture. Sunflower is also demanding for moisture, despite the fact that it is considered a drought–resistant plant. Due to the powerful root system, sunflower is resistant to short–term droughts.

Mainly early ripening, early mid ripening and mid ripening varieties and hybrids are cultivated in the northern part of Kazakhstan. Here the sunflower is sown in early May.

To study the dependence of the yield of sunflower seeds on the expected climate change, were selected Kostanay and Pavlodar regions, where the sunflower is cultivated in conditions of natural moistening (without irrigation), and for which a dynamic model of crop yield formation was adapted [11].

Calculations showed that in condition of the expected climate by 2030, the yields of sunflower seeds will make up an average of 102–106% of their current level (the average for 2000–2016) in the regions, but by 2050 – 100–105%. This means that, the yield of sunflower seeds is not expected to decrease until 2050. On the contrary, due to the optimization of the thermal regime, the yield of sunflower seeds can be increased by 2–6% by 2030, by 2050 – up to 5%, compared to current norms. This indicates the need for the gradual expansion of heat–loving crops in the Northern territories of Kazakhstan. Naturally, the introduction of adaptation measures and agricultural technologies will ensure higher yields of sunflower seeds than in current conditions.

SUMMARY

On the territory of Northern Kazakhstan, the duration of the vegetation period is increasing from north to south from 130 to 170 days. The sum of active air temperatures above 10C is from 2100C to 3400C. During the year 250–400 mm of precipitation falls. The humidification coefficient "K" makes 0.8–1.2 in the territory of North Kazakhstan region, 0.8–1.2 in Akmola region, 0.3–1.0 in Kostanay region, 0.6–0.9 in Pavlodar region. Repeatability of severe droughts, which cause significant losses to agriculture, raises from 5% (probability of 1 every 20 years) in the north of North–Kazakhstan region to 70% (probability of 1 every 2 years) in the south of Kostanay region. In conditions of further climate warming until 2050 in North Kazakhstan, an increase in thermal resources by 12–16% is expected. The moisture availability of the vegetation period will gradually deteriorate, with a decrease of 8–17%. This will lead to a shift of humidification zones to the north. The aridity of the climate will increase. As a result of the impact of a complex of climatic factors in the northern part of the country, the yield of spring wheat is expected to decline. However, due to the optimization of the thermal regime in the north of Kazakhstan, a slight increase in the yield of sunflower seeds is possible.

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SCF technologies for chromatography and micronization of drugs

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We demonstrate applicability of supercritical fluid (SCF) chromatography for the chiral separation of the substance of salbutamol sulfate (SS) racemic mixture and for production of the solutions with concentration of the active R-isomer greater than 98%. We have developed a SCF chromatography method for simultaneous qualitative determination of vitamins A and E in a mixture, which can be recommended for industrial implementation. We have also developed a method for SS micronization based on Supercritical AntiSolvent precipitation method (SAS). We were able to produce nearly spherical particles. Finally, we propose an optimization of conditions for production of micronized particles, which can be used for development of laboratory procedures for production of micronized substance.

Keywords: SCF technologies, salbutamol sulfate, vitamins A and E, AntiSolvent precipitation method, spherical particles, micronized particles

INTRODUCTION

Supercritical fluid technologies are chemical technologies that use substances, mostly gases, in a supercritical state. In this state the substances have special properties: they combine the solvent capacity of liquids and the high penetrating capacity of gases.

The combination of these properties makes it possible to use supercritical fluids as effective solvents in many technological processes, replacing hazardous organic solvents with safe substances in a supercritical state (water, carbon dioxide, etc.). The most promising applications of supercritical fluid technologies include chromatography, micronization and many others.

The paper presents the results of the chiral separation of the SS racemic mixture and the quantitative determination of vitamins A and E concentrations using supercritical fluid chromatography and dispersion of the drug substance that can be further used for production of an aerosol through supercritical fluid micronization.

MATERIALS AND METHODS

The chiral separation of the racemic mixture of SS and the quantitative determination of vitamins A and E were carried out using the Investigator Supercritical Fluid Chromatography system (Figure 1).

The system includes a pump module FDM-15 that features a CO2 pump and co-solvent pump, a 10-position column thermostat with a horizontal arrangement of the columns Analytical-2-Prep Column Oven, an autosampler Alias, a diode-matrix detector 2998 PDA, an automatic pressure regulator ABPR-20, a post-regulator electric heater and fraction collector featuring a blasting pump AFC Collection Module. The system allows to work with columns with internal diameter of up to 10 mm, and grain of sorbent of 3 m and above.

We used food-grade CO2 of 99.5% purity, compliant with GOST 8050-85, as the main eluant; methanol of "A.C.S. for gradient HPLC" purity (Chimmed, compliant with TU 2636-081-29483781-2015) as the co-solvent; and isopropylamine of "for synthesis" purity (Merck), as the dynamic modifier.

Our system was equipped with Chiralpak IG 5 m, 1504.6 mm chromatographic column and Chiralpak IG 5 m, 104 mm precolumn.

Samples were placed in 2 ml chromatographic vials. The resulting fractions were collected into 100 ml glass jars with plastic lids.

The software allowed us to create a sequence of injections of the SS solution, and to set the time of the sample

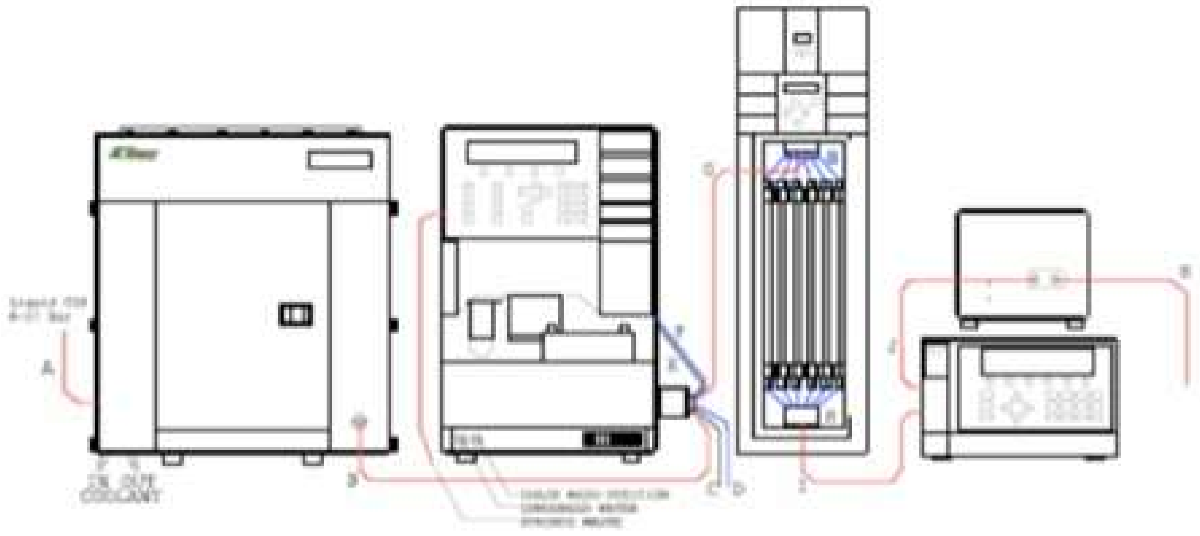

FIGURE 1. . Overview of the Investigator Supercritical Fluid Chromatography system

injection, the collection conditions, the time lag between sample insertions, and the collector number. Then we ran the sequence of injections. Upon the sequence completion, the fractions were retrieved from the collectors.

The chromatograph was then switched to analytical mode, and enantiomeric purity of the fraction samples was determined.

For development of the method of analysis of vitamins we used the drug Aevit (Altavitaminy) containing 0.1 ml (100000 ME) of 55% retinol palmitate oil and 0.1 g of -tocopherol acetate.

The qualitative determination of vitamins was carried out using the using the Investigator Supercritical Fluid Chromatography system (Waters Corporation). The parameters of the method were as follows: pressure in the system 120 bar, CO2 (food-grade) as the mobile phase, isopropyl alcohol (high grade purity) as the co-solvent, flow rate 3 ml/min, thermostat temperature 35 oC, co-solvent concentration 10%, XBridge C18 5 m 4.6x150 mm as the column, UV detector, detection lengths 292 nm and 325 nm.

The hardware schematic diagram for micronization (SAS) by the Waters Corporation company is shown in Figure 2.

RESULTS AND DISCUSSION

0.1. The chiral separation of salbutamol sulfate using supercritical fluid chromatography

Supercritical fluid chromatography (SFC) is a type of chromatography related to high-performance liquid chromatography (HPLC) that uses subcritical or supercritical fluid (SCF) as the main component of the mobile phase (MPh), most often supercritical carbon dioxide (SC-CO2). Supercritical fluids have lower viscosity and high diffusion rates than liquids. Also, supercritical fluids possess some special properties, such as controllable solvent capacity, special heat transfer mechanisms, etc. This combination makes SCF an attractive environment for chromatographic separation. Due to the low viscosity, SCF elution in the SFC can be done at the flow rates that are 2-4 times higher than in the HPLC. Due to the high diffusion rates, the mass exchange processes in the sorbent pores are able to progress at the appropriate speed, and chromatographic efficiency is maintained at a high level. The advantage in speed and productivity is particularly relevant in chromatography of the structurally close, hard-to-separate compounds, including enantiomeric substances and their racemic mixtures, such as salbutamol (2-tert-butylamino-1-(4-oxy-3-oxymetilphenyl)-ethanol).

Salbutamol in the form of salt is a component of modern drugs for bronchial asthma and chronic bronchitis. This drug product for chronic obstructive lung diseases exhibits broncholytic and tocolytic action and is used as a long-acting prophylactic drug and as a relief of bronchial asthma attacks. Drug products based on 2-tert-butylamine-1-(4-oxy-3-oxymethylphenyl)-ethanol are in stable demand on the pharmaceutical market, as in most cases they have long-term, often life-time application. The most effective and most popular form of the drug products on the market is aerosol.

2-tert-butylamine-1-(4-oxy-3-oxymethylphenyl)-ethanol has chirality characteristics. Enantiomers (the structural formulas are shown in Figure 3) are biologically active. The R-isomer provides the necessary therapeutic effect, the

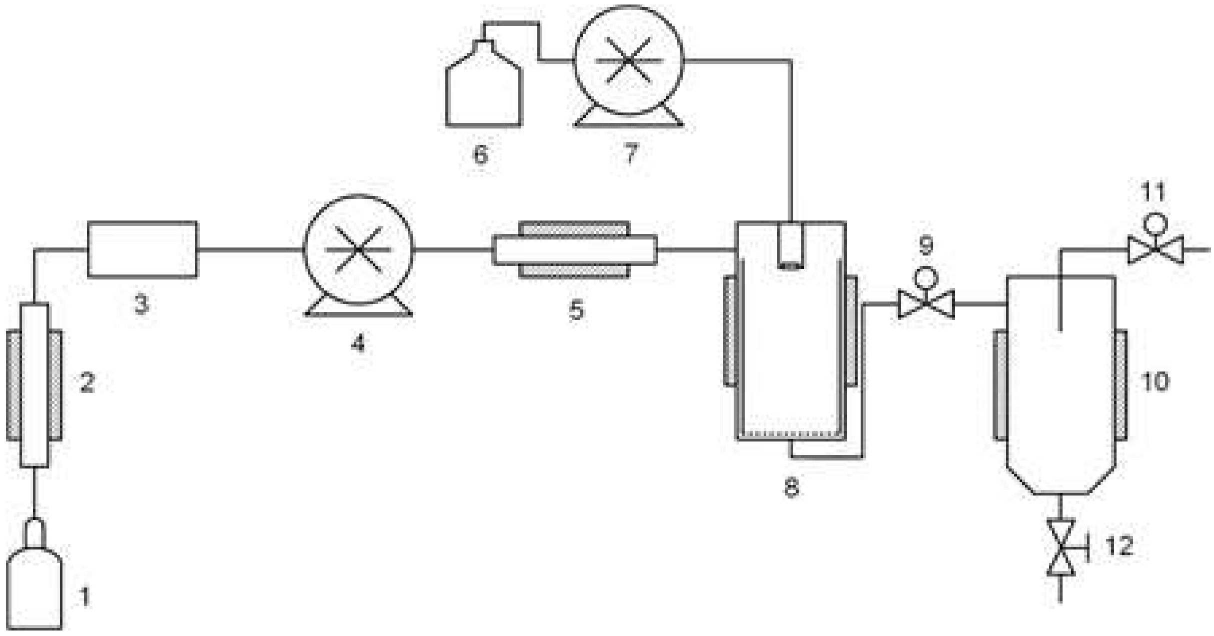

FIGURE 2. . Schematic diagram of the laboratory facility for supercritical anti-solvent precipitation: 1 – CO2 supply, 2 – cooling heat-exchanger, 3 – mass flow meter based on Coriolis effect, 4 – CO2 pump, 5 – electric heating heat-exchanger, 6 – initial solution supply, 7 – solution pump, 8 – precipitation chamber, 9 – automatic back pressure regulator, 10 – cyclone separator, 11 – manual back pressure regulator, 12 – drain valve

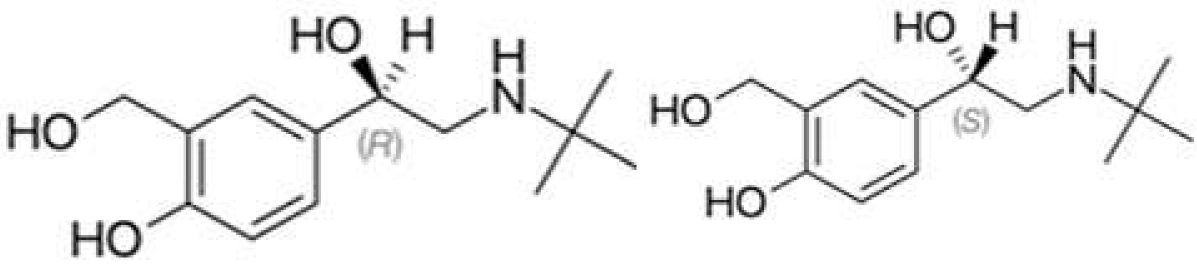

FIGURE 3. Structural formulas for enantiomers of 2-tert-butylamino-1-(4-oxy-3-oxymethylphenyl)-ethanol

S-isomer has no broncholytic activity [1], and also has a negative effect on the human body [2-4], such as arrhythmia, tachycardia, inflammatory processes. The metabolism of the S-isomer is 10 times slower than that of the R-isomer, it accumulates in the lungs and bronchus, which can lead to bronchial disfunction [3,4]. The use of enantiomerically-pure R-isomer of 2-tert-butylamino-1-(4-oxy-3-oxymethylphenyl)-ethanol or its salt is preferable in clinical practice to the use of a racemic mixture.

Obtaining enantiomerically-pure drugs is an important sphere of modern pharmaceutics. However, separating enantiomers from the same compound is a technologically complex task. It is usually solved by development of an enantioselective synthesis, through a biotechnological process, or through liquid chiral chromatography, which is a labor-intensive and costly process with low productivity. There is a series of drugs based on enantiomerically pure 2-tert-butylamino-1-(4-oxy-3-oxymethylphenyl)-ethanol produced by an Indian pharmaceutical company Cipla Ltd under the brand Levolin in the form of sulfate, by an American pharmaceutical company Sunovion Pharmaceutical Inc. under the brand Xopenex NFA in the form of tartrate. The 2-tert-butylamino-1-(4-oxy-3-oxymethylphenyl)-ethanol substance used in their production is obtained through multi-stage enantioselective synthesis [5] followed by subsequent recrystallization in order to get the required polymorphic modification [6], or recrystallization of racemates from solutions with optically active acids, such as tartaric [7].

We have developed a technique for the chiral separation of the substance of the racemic mixture of SS on the semi-preparative supercritical fluid chromatograph Investigator SFC System produced by Waters Corp.

As a result of a series of experiments, we have obtained the solution of an R-isomer of SS from a racemic mixture using supercritical fluids (figure 4).

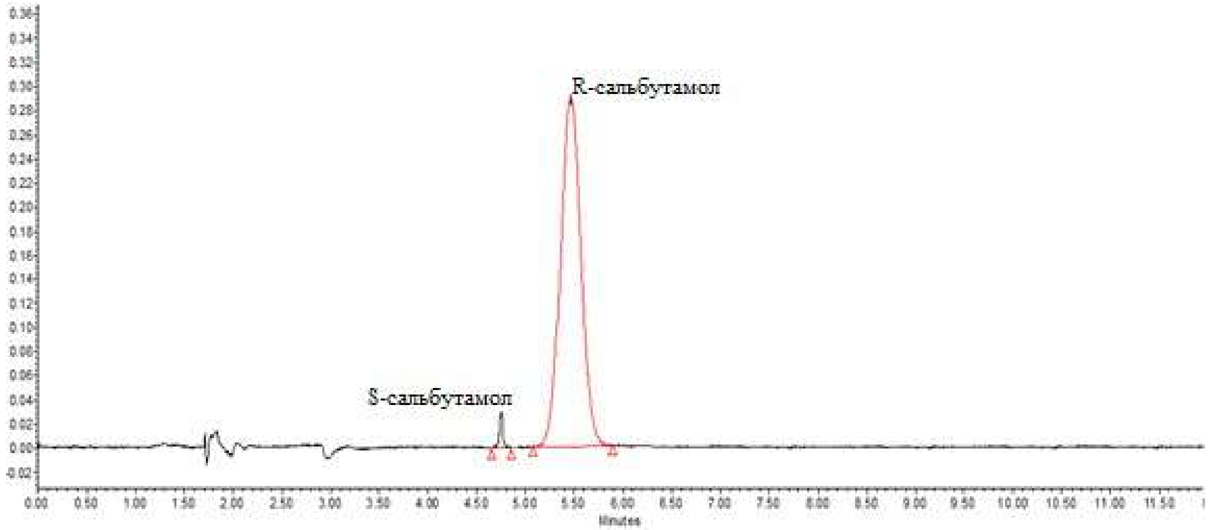

FIGURE 4. Chromatogram of a sample of the collected fraction of the SS R-isomer solution

TABLE 1. Results of experiment 4 in testing the laboratory method for obtaining the solution of the R-isomer of the SS from a racemic mixture using supercritical fluids (Chiralpack IG 5 m 1504.6 mm column, isopropylamine DM)

Sample number	R-isomer content,%	Average	Standard deviation
1	98.74	98.88	0.23
2	98.81	98.88	0.23
3	99.02	98.88	0.23
4	98.93	98.88	0.23
5	98.88	98.88	0.23

We conducted a series of experiments to test the laboratory method of separation using semi-preparative SCF-chromatograph. The sample size of each experiment for a single measurement was 5 injections. The results of one of the experiments are presented in Table 1.

As a result of laboratory method testing, solutions of the R-isomer of the SS are obtained from a racemic mixture using supercritical fluid chromatography containing more than 98% of R-isomer.

The SS content in the solution was confirmed by UV spectroscopy using a method developed earlier [8].

The specific rotation of the solution containing more than 98% of R-isomer of 2-tert-butylamino-1-(4-oxy-3-oxymethylphenyl)-ethanol was -36,9.

0.2. Express method of vitamin A and E determination

Retinol (Vitamin A) is a liposoluble vitamin-like substance of plant origin from the group of retinols. Due to the presence of a large amount of unsaturated bonds, it participates in activation of oxidation-reduction processes (redox), stimulates synthesis of pyrimidine and purine bases. It also participates in the energy supply for metabolism by creating favorable conditions for the synthesis of ATP [9, 10].

Vitamin E (-tocopherol) is a liposoluble vitamin of plant origin from the group of tocol. It is a universal protector of cellular membranes, protecting them from oxidative damage. The antioxidant properties result from the ability of the highly reactive hydroxyl of chromane nuclei to react directly with free radicals of oxygen (O2, NO, NO2) and unsaturated fatty acids (RO, RO2) [10, 11].

At present, the physiological need for vitamin A for adults ranges from 700 to 900 g/day [12], the need for vitamin E for adults is 20 to 30 mg/day [13].

Drugs of plant origin containing liposoluble vitamins A and E are widely used in medical practice. Both the drug products and biologically active food supplements can be found on the market. The 14th edition of the State Pharmacopoeia of the Russian Federation includes articles on -tocopherol acetate [14], retinol, retinol acetate, retinol palmitate [15].

In most cases, the end product contains a mixture of different vitamins rather than individual vitamins. This applies both to the drug products and the biologically active food supplements.

The express method of simultaneous qualitative determination of individual vitamins in a mixture is an important

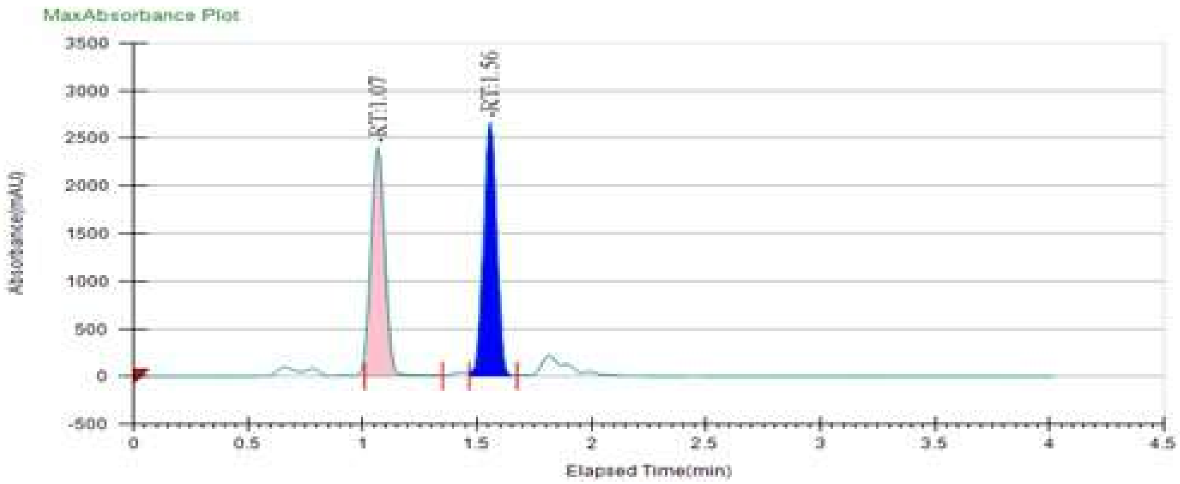

FIGURE 5. Selectivity of separation of the vitamin A and E mixture (RT:1.07 - vitamin A, RT:1.07 - vitamin E)

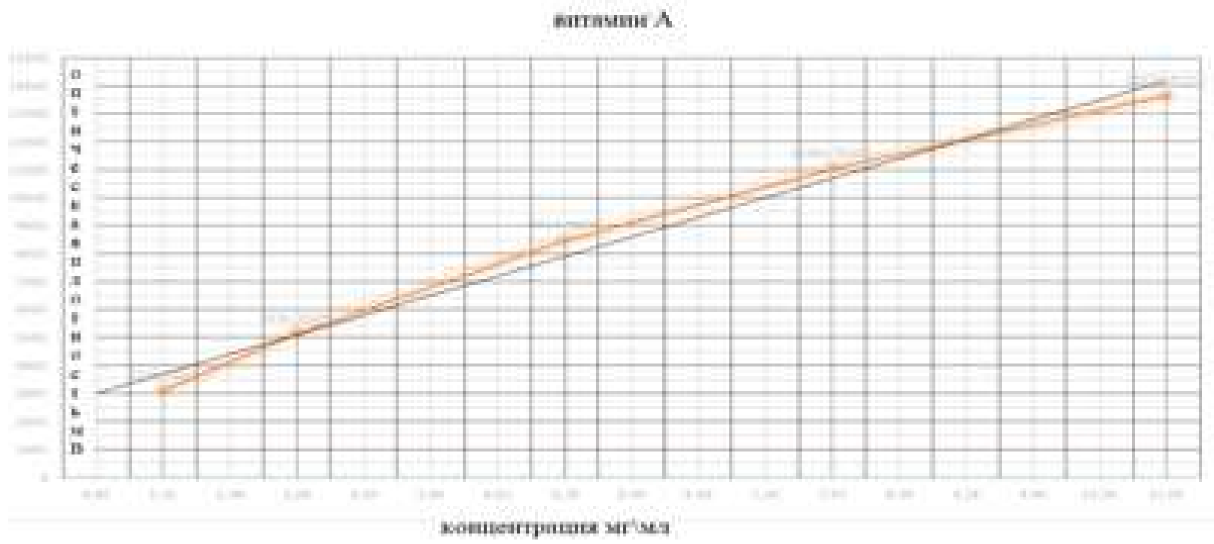

FIGURE 6. . Dependence of the optical density on the vitamin A concentration

condition for determining the quality of pharmacologically active substances as well as different types of products of plant origin. Chromatogram of separation of the vitamin A and E mixture is presented in Figure 5

Measurement range for vitamin A is 1,600 to 40,000 IU (480 – 12,000 mg). Measurement range for vitamin E is 0.16 mg to 20 mg.

Linear relation between the optical density and the concentration can be observed in the whole range of the studied concentrations (Figures 6,7).

At present, UV-detecting HPLC method is used for the qualitative and quantitative determination of vitamins A and E. The movable phase uses isopropyl alcohol, sorbent C18, d-5 m.

The main disadvantage of the method is its duration of 10 to 15 minutes for each measurement and the high cost of the applied eluents.

The method of simultaneous determination of vitamins A and E through supercritical fluid chromatography numerous advantages over the method of determination of vitamins by means of high-performance liquid chromatography. The main advantages of the methodology include: one-time determination takes 3-4 minutes; use of the reagents of the class HP as eluents; extremely simple preparation (dissolution of the test sample). This technique can be modified for isolation of pure vitamins from vegetable extracts.

Thus, the developed method of simultaneous qualitative determination of vitamins A and E in the mixture can be recommended for wide-scale introduction. The SFC method is comparable to the HPLC method for sensitivity and reproducibility.

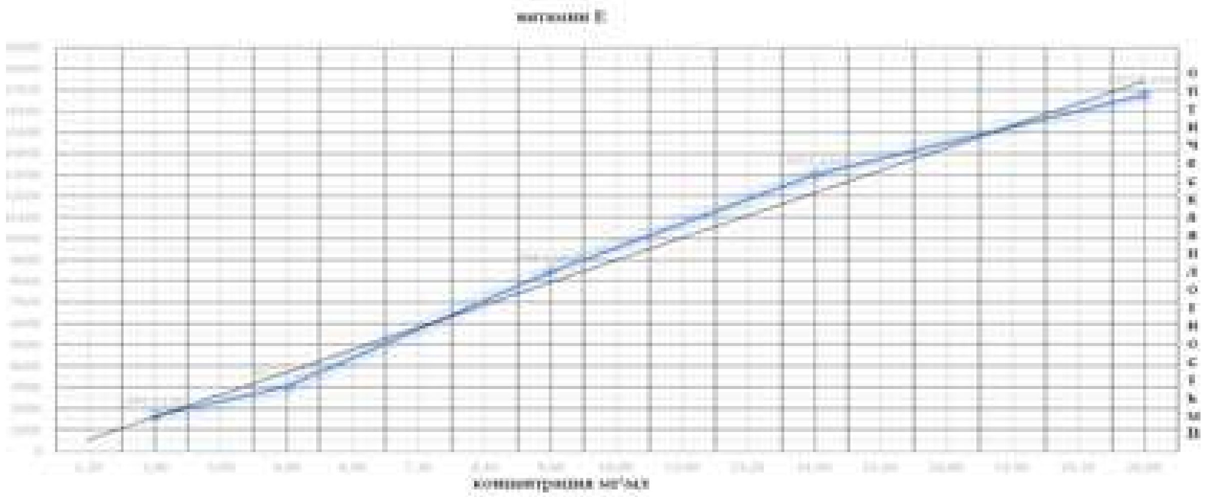

FIGURE 7. .Dependence of the optical density on the vitamin E concentration

0.3. Micronization of the drug substance by supercritical antisolvent deposition

Salbutamol is one of the active pharmaceutical ingredients (API) for which the inhalation dosage form is the most convenient and effective way of administering the drug into the human body [16]. Its key advantages over the oral treatment are the targeted delivery of the API (for example, to the upper respiratory tract), the high rate of absorption of the API into the bloodstream, and the reduced likelihood of undesirable side effects [17]. Control of the size and shape of the API solid particles is critical in the manufacture of inhalation drugs. The size determines the delivery point of the AFI during inhalation. In order to deposit the drug into bronchi, particles of 1 – 5 m, preferably 2-3 m are required; to be deposited in lungs, particles of submicron size. The shape of the particles affects their aerodynamic characteristics and the rate of absorption.

Sphere-shaped particles with the least mechanical risk of soft tissue damage due to lack of sharp edges are generally considered preferable [18–21].

The supercritical antisolvent precipitation (SAS) method belongs to the group of solvent methods using supercritical fluid technologies and is used to produce microparticles of substances insoluble in SC-CO2, the latter being a precipitator, an antisolvent, and causing the crystallization of the target substances from the solution upon contact.

The SAS method allows to control the size and morphology of the microparticles produced.

A number of studies have shown that for crystalline substances the relationship of size and morphology to the values of SAS parameters is often nonmonotonic, and, when developing specific applications, the joint influence of the parameters [22-26] should be taken into account.

Currently, particles of spherical morphology have been obtained in the process of micronization of SS using the SAS method [27, 28]. Experimental studies have been conducted on the SAS-precipitation of SS from various solvents in the SC-CO2 environment, and spherical particles have been obtained.

The pressure, solution flow rate and SS concentration in the solution have a significant influence on the morphology and size of the SS particles produced by the SAS method. By modifying various parameters of the SAS process, it is possible to obtain SS particles ranging 0.7 m to 8.5 m of needle-shaped, spherical or closely related morphology, including particles that meet the size and morphology requirements for inhalation forms of preparations. The dependence of the particle average size on the SS concentration in the solution is nonmonotonic. Of the three solvents – methanol, hexafluoroisopropanol and dimethyl sulfoxide (DMSO) – the latter is the best for synthesis of micron-sized particles. Conditions for the production of micronized SS particles of a size of 1¡d¡5 m and with morphology close to spherical were developed and optimized. Laboratory procedures for the production of micronized SS substance have been developed.

Figure 8 presents the diagram of the SS microparticle production process.

The process consists of 14 operations, including: preparation of the salt crystals for precipitation; dissolution of the crystals of the R-isomer of SS; micronization of the salt of the R-isomer of SS; the system preparation and setup for the operating mode; stabilization of temperature and pressure in the system; the salt solution of the R-isomer of salbutamol sulfate is supplied to the working vessel periodically; collection of the micronized R-isomer of salbutamol salt; shutdown of the solution supply pump; supplying an extra amount of CO2 through the system under pressure

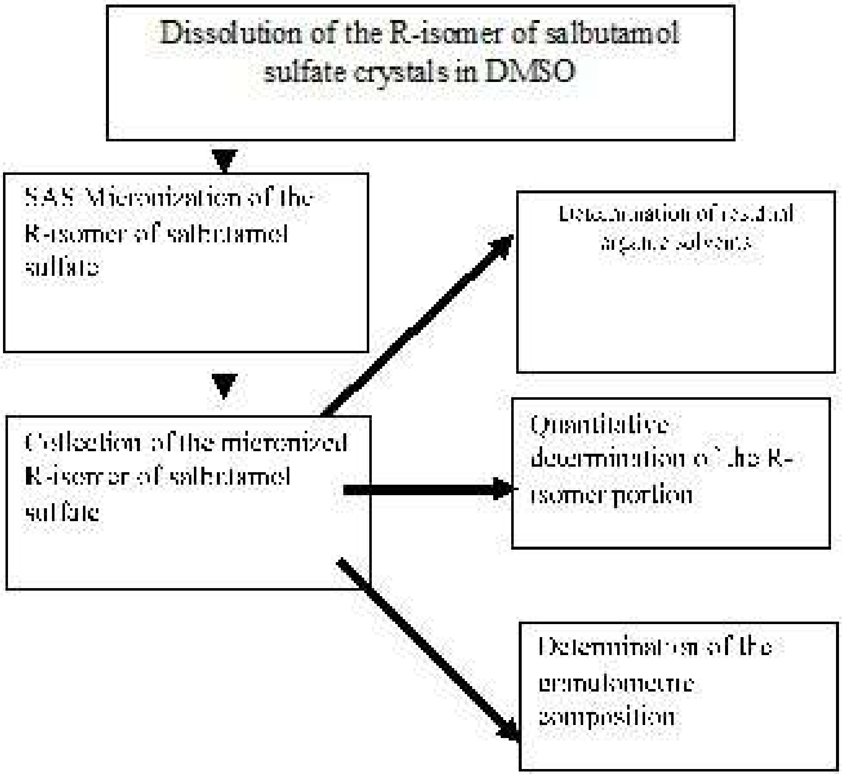

FIGURE 8. .Schematic diagram of SS microparticle production

to flush the residues of the working solution and the solvent from the system; operating pressure reduction in the system; shutting off the CO2 supply; opening of the drain valve of the working vessel; equalization of pressure in the working vessel with the atmospheric pressure; collection of micronized powder of the R-isomer of SS.

The following control measurements are carried out: determination of the yield of the micronized R-isomer of SS; granulometric control of the obtained micronized R-isomer of SS; quantification of the R-isomer of SS in powder; determination of residual organic solvents (methanol, TEA, DMSO, ethyl acetate).

CONCLUSIONS

Thus, a method of synthesis of microparticles of salbutamol sulphate with morphology close to spherical is developed and tested in the course of the study. Data have been obtained for the development of laboratory procedures for the production of micronized substance of salbutamol sulfate

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The method of space monitoring of oil pollution on the sea surface on the example of the Caspian Sea

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The article presents the experience of developing the method for space monitoring of oil pollution on the sea surface using the example of the Caspian Sea within the Atyrau region (hereinafter the method). Today, the level of development of technologies for remote sensing of the Earth (hereinafter - ERS) and data processing technologies in geographic information systems (hereinafter - GIS) allows one to create accurate digital models as well as scientific and applied methods for analyzing effects of oil pollution on the sea surface and coastal ecosystems.

The paper describes the main approaches and methods of modern satellite monitoring of oil pollution of the sea surface and the development of a digital map of "oil pollution facts in the KSCS aquatorium within the Atyrau region."

A wide amount of data allowed us to analyze existing methods for detecting oil pollution and to choose the optimal solutions to the problem of detecting and predicting oil and oil product spills. Considerable attention is paid to the practical use of remote sensing and GIS data for monitoring oil pollution. Based on the analysis of the successfully applied detection methods, the most exemplary and diverse solutions of space monitoring of oil and oil products extraction and transportation areas were identified. The developed Methodology is intended for a wide range of users and can be considered as an information system that contributes to the accumulation of scientific knowledge, its display, analysis, and updating. The methodological foundations of the Method can be used to conduct similar studies at other water bodies of Kazakhstan.

Keywords: Earth remote sensing, Geoinformation systems, Kazakhstan sector of the Caspian Sea, Oil / oil-containing products, Monitoring of oil pollution processes

1. INTRODUCTION

The UN member states at the UN summit of September 25, 2015 adopted the Agenda for Sustainable Development for the period 2015-2030 consisting of 17 global sustainable development goals aimed at conserving natural resources and solving problems associated with climate change.

The adoption of the historic Convention on the legal status of the Caspian Sea at the last Summit of the Heads of State of the five Caspian countries (Aktau city, August 12, 2018) laid a solid foundation for the beginning of a qualitatively new stage of multilateral international cooperation, which will contribute to the sustainable development of the Caspian region.

We believe that sustainable development in the Caspian is synonymous with safe development, which is based on the ability to anticipate and prevent threats and dangers such as pollution of the coastal zone and sea water, environmental degradation, desertification and degradation of coastal landscapes, destruction of coastal infrastructure, decrease in stocks of biological resources, threat to biodiversity as a whole.[1]

The Caspian Sea is an inland continental drainage reservoir with high sensitivity and vulnerability to anthropogenic impact. Currently, in the water area of the Kazakhstan sector of the Caspian Sea (hereinafter - KSCS) active development of oil and gas fields continues. Significant natural, technical and labor resources are involved in the development of KSCS. Intensification of work on the development of oil and gas fields of the Caspian shelf increases the risk of technological disasters. This justifies the need for monitoring oil pollution in the KSCS aquatorium using remote sensing devices installed on artificial Earth satellites (hereinafter - AES).

As part of the study, the authors developed a new method based on a comprehensive analysis of satellite information on oil pollution of the sea surface by distinguishing features, taking into account the influence of dynamic and circulating processes on their distribution, as well as created a digital map of "oil pollution facts in the KSCS aquatorium" and created an automated workstation (hereinafter - AWP).

The aim of this work is to develop a technique for space monitoring of oil pollution on the sea surface using the example of the Caspian Sea within the Atyrau region, as well as to create an information-analytical system with the possibility of independent monitoring of oil pollution processes in the KSCS aquatorium within the Atyrau region for the Municipal Public Institution "Situation Center" of the Atyrau region's Akim administration.

The objectives of the study are:

1) Analysis of modern methods of space monitoring of oil pollution processes in the sea water and inland waters;
2) Study of the influence of dynamic and circulating processes on their distribution;
3) Determination of oil pollution process indicators using remote sensing;
4) Creation of a digital map of "oil pollution facts in the KSCS aquatorium within the Atyrau region."

Relevance and subject of research. The main pollutants of the sea are oil and oil products. In the open sea, they cause significant, sometimes, irreversible changes in its properties. Oil pollution covers huge sections of the water surface, disrupting oxygen, carbon dioxide and other types of gas exchange.

These changes cause deterioration in the state and bioproductivity of marine flora and fauna. Also, seasonal sea level fluctuations and surging phenomena caused by the shallow North Caspian shelf and the lowland of its adjacent coast increase the impact of the effects of oil pollution on coastal ecosystems, on social, economic and industrial facilities.

When solving issues related to the environmental safety of the entire region, the priority is to prevent and timely detect environmental pollution as a result of unauthorized discharges or accidental oil spills.

The problem of oil pollution as a result of human activities associated with the use of oil and oil products is undoubtedly one of the most significant environmental problems not only in Kazakhstan, but across the globe. Oil pollution of water and bottom sediments is mainly caused by routine maintenance during oil transportation, emergency spills during transportation and oil production offshore, the discharge of industrial and domestic wastewater, and garbage.

In this regard, one of the most important tasks of scientific and applied research is the development of effective methods for the detection and timely identification of oil pollution.[2]

According to statistics, shipping accounts for 45% of the oil pollution of the ocean in the global waters, while oil on the shelf accounts for only 2%, so shipping, including oil transportation and transshipment at terminals, has the main negative impact on the marine environment and the coastal zone. The main sources of pollution from ships are oil-containing flushing and ballast water from the premises of cargo pumps.

It is believed that due to the expansion of oil production on the shelf and the growth in the volume of shipping, the oil pollution of the World Ocean will increase both due to accidents at drilling rigs and as a result of disasters with supertankers and the discharge of untreated from oil products wastewater. According to some reports, every year millions of tons of oil and oil products enter the World Ocean.[3]

According to UNESCO forecasts, increase in the number of accidents involving the release of oil and oil products is expected in the foreseeable future. This is due to the physical deterioration of the global transport fleet and oil production platforms. Unfortunately, the forecasts of scientists for today come true, and the fight against pollution of the oceans has become one of the most important environmental problems.[4]

The lack of rapid detection and timely response to oil and oil products emissions as well as the inaccessibility of regular monitoring of the aquatic environment state have been the key reasons for the mass death of marine flora and, in particular, phytoplankton. Phytoplankton is the main consumer of carbon dioxide and a supplier of about 50% of oxygen to the atmosphere, and it also forms the basis of marine organisms' food supply. Such limiting factors did not allow one the widespread practical use of various methods for eliminating oil spills in the marine environment.[5]

Currently, oil spills are detected using remote sensing data, which allows one to quickly respond to leaks of oil and oil-containing elements onto the water surface.

WORLD EXPERIENCE IN APPLYING MODERN SATELLITE MONITORING OF OIL POLLUTION OF THE SEA SURFACE.

At the present stage, monitoring the environmental safety of not only the Caspian Sea, but also of the entire oceans, takes as its basis the acquisition and interpretation of Earth remote sensing data for the detection of oil pollution. Recently, a large number of satellites with scientific equipment on board operating in different ranges of the electromagnetic spectrum have been launched all over the world. A huge amount of information received from satellites is used not only for scientific purposes, but also for solving many economic and environmental problems. Oil pollution of world waters is constantly increasing. This is due, first of all, to an increase in the volume of shipments by sea, in particular, the transportation of exported oil by water, the commissioning of new oil terminals and offshore rigs, and the discharge of polluted waters by rivers.[6]

As part of the development of space monitoring of oil pollution of KSCS within the Atyrau region, previously published problems of monitoring and timely response were examined using examples of the areas of the Mexican, Kola and Persian Gulfs, as well as the Caspian Sea.

Gulf of Mexico. April 20, 2010 was the black day of the calendar for British Petroleum. A floating drilling platform in the Gulf of Mexico, 80 km off the coast of Louisiana, completed drilling at Macondo when it was hit by a massive explosion. The explosion led to the destruction of the drilling platform, its flooding and the formation of a gigantic oil slick of thousands of square kilometers on the sea surface in the northeastern part of the bay. Immediately after the accident, filming of the scene of the accident from space began with optical and radar satellites. Continuous daily surveys made it possible to precisely determine the size and configuration of the spot, the direction of its drift, and a number of other characteristics.

Indeed, in the elimination of the disaster, remote sensing data played one of the main roles - both in monitoring the spill itself and in assessing its impact on the environment. As a result, more than 650 satellite images were obtained and analyzed. For the first time, the advantages of a multi-sensor approach for monitoring the catastrophic oil spill were fully professionally implemented, including the ability of various remote sensing sensors to receive quasi-synchronous images from space in different spectral ranges, with different visibility and resolution. In addition, based on remote sensing and GIS data, special interactive tools were created that visualized images from space, the spill itself, as well as its various parameters and characteristics, including environmental sustainability indices (ESI indices) for the coasts of Louisiana, Mississippi, Alabama and Florida. In particular, a number of online services have been created based on remote sensing data and providing visual information about the spill in real time. US research institutes that simulated the Gulf of Mexico water circulation to determine the most probable oil slick drift trajectories (6 different models were used) also compared the results with remote sensing data.

This environmental catastrophe took the world community by surprise and revealed the urgent need for scientific and applied solutions in the field of remote sensing and GIS technology to collect and consolidate information in a spatial context, providing tracking of consequences and timely response. The Gulf of Mexico has become a kind of a test site, which used the technologies of all leading space agencies, which created an erratic data stream and a number of unstructured methods for identifying and verifying oil pollution. But in a crisis situation, empirically, and an analysis of the materials obtained, the foundation was laid for the formation of modern techniques for space monitoring of oil pollution processes in world waters.[7]

Kola Bay. Satellite monitoring of oil spills of the Kola Bay began in June 2011. Space data, previously analyzed on-line by the SCANEX specialists, were sent to the monitoring center of the State Educational Establishment for Civil Defense and Public Safety of the Murmansk Region. They were actively used in the work of the monitoring and forecasting center of the Murmansk State Civil Emergency Situations for monitoring oil spills in the water area and in the coastal zone of the bay in 2011–2014. Monitoring of the bay lasted four years. Satellite images and products, obtained during monitoring, were uploaded to the geoportal with access via the Internet. To detect and identify film pollution of the sea in the Kola Bay, data from space-based radar imaging of the Radarsat-1 and Radarsat-2 satellites were used, which had been taken on-line at the SCANEX UniScan-24 and Uniskan-36 ground receiving stations. These satellites were equipped with side-scan SARs, which make it possible to obtain radar images of the sea surface regardless of the light and weather conditions, which was an important advantage in the specific physical and geographical conditions of the Murmansk region.

As a result, according to the results of four-year satellite radar monitoring using GIS for the Kola Bay, maps of the actual distribution of film pollution were first created, their spatial and temporal distribution was analyzed, and the main sources of oil pollution were identified. It is shown that extensive film formations of oil and oil products were periodically observed in the bay. The main sources of pollution were enterprises of the Ministry of Defense, maritime transport and housing and communal services, as well as coastal oil storage facilities and tank farms. A significant contribution to total pollution was made by the systematic discharges of various pollutants from ships passing through the water area of the bay. According to the monitoring results, the Kola Bay can be considered one of the "hot spots" of the Russian Arctic according to the degree of oil and oil products contamination.[8]

Persian Gulf. Based on the analysis of integrated pollution maps, experts concluded that the Persian Gulf was subject to serious oil pollution, mainly as a result of intensive oil production, oil transportation, and active shipping. The current situation threatens the ecological state of the bay, even with the formal observance of global standards and environmental requirements. A systematic radar survey of the water area can help the environmental authorities of the Persian Gulf countries to conduct daily monitoring of the Gulf, and can also be used as evidence.

Currently, satellite radar monitoring continues to be an effective tool for monitoring oil pollution, including the Persian Gulf. An analysis of the radar data collected during monitoring made it possible to visualize the extent of pollution of one of the most unique water bodies in the World Ocean and provided new information for understanding the essence of the problem.[9]

Caspian Sea. The Republic of Kazakhstan also supports the global trend to combat pollution of water by oil and oil products. In 2011, the Mekensak Research and Production Center, together with Sovzond specialists, performed space-based radar monitoring of oil spills in the water area of the Aktau port according to the satellite constellation COSMO-SkyMed (Italy). Space monitoring of oil spills in the waters of a major port like Aktau seems to be necessary to maintain environmental safety in the region.

In the Caspian Sea, many oil and gas fields are being developed. Proven oil resources in the Caspian Sea are about 10 billion tons, total oil and gas condensate resources are estimated at 18–20 billion tons. The Aktau city, located on the eastern coast of the Caspian Sea, is the largest cargo and the only port in Kazakhstan intended for international crude transportation oil and oil products.

The image dated September 22, 2011, revealed six oil spills on the surface of the water, including two oil spills directly in the vicinity of the Aktau port. All six discovered oil spills were delivered to the customer in the form of a vector polygonal shapefile (vector format for storing the geometric location and attribute information of geographical objects). In the attributes of each oil spill, the spill area is recorded in sq. km, date and time of detection.[10]

An analysis of world-wide space monitoring techniques for detecting oil pollution in four different water areas accumulated a massive amount of data from long-term satellite observations of the Caspian Sea, the Mexican, Kola and Persian Gulfs. These data were highly important in the analysis and timely response, both in monitoring local spills and in assessing their environmental impact.

RESULTS.

Determination of satellite technical characteristics and identification of sea surface oil pollution indicators.

In order to effectively monitor oil pollution, the Method is based on specific technical solutions that take into account natural indicators of oil pollution processes. When identifying oil spills, parameters such as shape, size, geographical location, surface wind speed, as well as the direction of the surface current, wave height, and other indicators are considered.

Choosing the optimal satellite.

An important component of the Method is the choice of satellite constellation, in particular, such technical characteristics as a sensor, date of recording, spatial resolution, spectral properties, processing level. The right choice of the listed characteristics will allow one to get the most reliable data, and will also serve as a trustworthy source of information for further analysis and interpretation of oil pollution.

Decryption and entry into the database.

The stage of processing, analysis and decoding of the obtained satellite images is fundamental to the Method. A well-formed data processing strategy allows one to empirically derive the most effective algorithms for the analysis and verification of oil pollution facts.

The technique of space monitoring of oil pollution on the sea surface on the example of the Caspian Sea.

The development of scientific foundations and a methodology for the quantitative assessment of the ecological state of marine water areas and the determination of pollution parameters and the dynamic characteristics of the KSCS aquatic environment within the Atyrau region based on a comprehensive analysis of satellite information is an urgent task today. In this regard, the authors of the study conducted a step-by-step cycle of actions for obtaining and processing satellite images with the possibility of detecting and identifying oil pollution processes in the KSCS water area within the Atyrau region. The results of the study were introduced at the "Situational Center" of the Atyrau Region Akim's administration for continuous and systematic monitoring of the environment, operational detection of oil spills in the areas of offshore oil platforms, loading and unloading tankers, as well as on their sea routes.

Satellite image processing.

Processing of satellite images includes two stages – the preliminary and the main stages. At the first stage, preliminary processing of remote sensing data takes place, which includes geometric correction of satellite images, radiometric calibration of images, restoration of missing pixels, contrasting, etc. At the main stage, visual and automatic methods are used to decode the images.[11]

Decryption is performed using top-down approach. The objects in pictures are distinguished by direct and indirect decryption signs. Direct signs include shape, size, color, tone and shadow, as well as a complex unifying feature - the image $Fig.1$. Indirect signs are the location of the object, its geographical proximity to potential sources of oil pollution, traces of interaction with the environment.[12]

FIGURE 1. An example of the oil pollution detection in an optical image.

Joint analysis of satellite radar and optical data.

In radar images, the vast dark areas of attenuation of the backscattered signal, corresponding to the areas of weak near-surface wind, stand out as dark areas.[13]

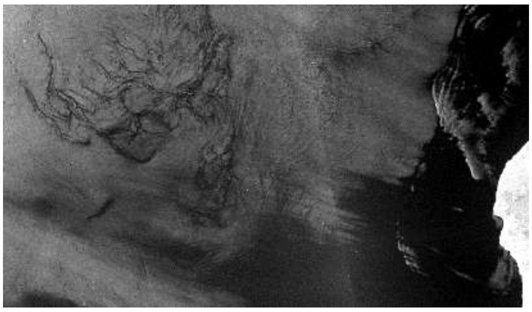
The identification of slicks of oily films in this image is extremely difficult. The ambiguities in the interpretation of such radar data and the detection of oil pollution of the sea surface are solved on the basis of the combined use of satellite radar data and data obtained in the visible and near infrared regions of the electromagnetic spectrum. The data of the optical range sensors contain additional information about processes and phenomena occurring on the sea surface, including the areas of local wind attenuation, i.e., in those areas to which dark areas of reduced intensity of the backscattered signal correspond to in the radar image.[14]

When speaking about the problem of identifying biogenic films, it is worth noting that in the data of the optical range, oil-containing slicks and slicks caused by biogenic films appear in different ways. In a color-synthesized image, oil-containing slicks have increased brightness and appear as homogeneous structures, while slicks of biogenic origin films are not detected [15](Fig. 2). When analyzing optical and radar images, observed contrasts are caused not only by attenuation of surface waves, but also by differences in the optical characteristics of pure water and oil-containing films, which contributes to their identification.

Expert analysis

Expert analysis allows one to solve problems that cannot be solved using usual analytical way, including:

- Choosing the best solution among available;
- Forecasting the development of the process;
- Search for possible solutions to complex problems.



a)Satellite radar image

b)Optical satellite image

FIGURE 2. Elimination of nutrient spots using optical satellite images.

Expert analysis is the most effective method for detecting oil spills since this approach involves the identification of film-based oil contaminants through photo-interpretation.[16] Photointerpretation distinguishes oil spills from other natural emissions or stains. The distinction seems difficult in the presence of natural oil spots or areas with low wind speeds. In these situations, a more detailed analysis is needed where several factors need to be considered. The most important of which are the state of the wind, period of the year, shape analysis, spot size and general morphology of the observed area.

Factors Affecting Oil Pollution Identification

Rain. The difficulty is caused by the attenuation of short surface waves (Bragg waves) - turbulence created in the upper water layer by falling raindrops (Fig. 3). However, it cannot be completely ruled out that some dark spots in the rain cyclone are the result of mineral oil films. Since this may be an accumulation of oil due to local winds associated with the rain cyclone and the current.

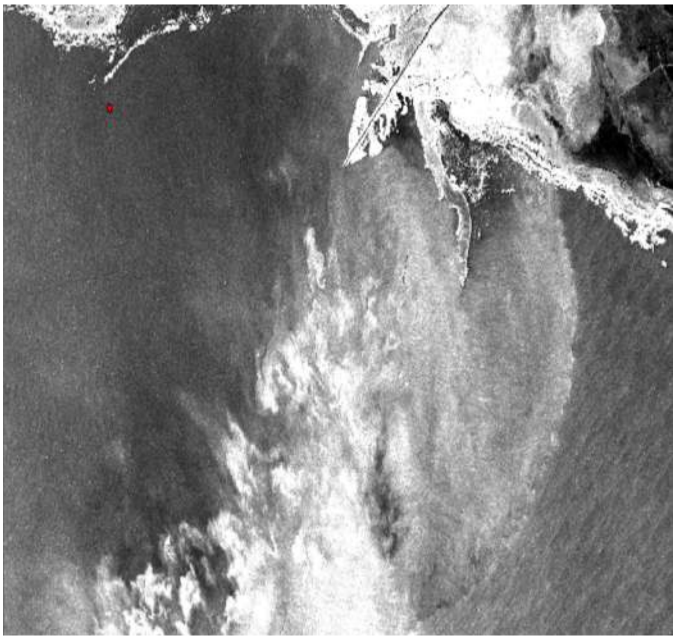


FIGURE 3. Turbulence of water in the upper layer of the sea surface.

Wind and current. A strong wind (more than 7 m/s) breaks a slick into fragments. The wind drives a thick layer to the leeward side, the current gives direction, that is, the waves extinguish the wind signal. On the other hand, at high wind speeds, usually above 7–8 m/s, biogenic surface films disappear from the sea surface, since they are "washed off" by waves (Fig. 4).

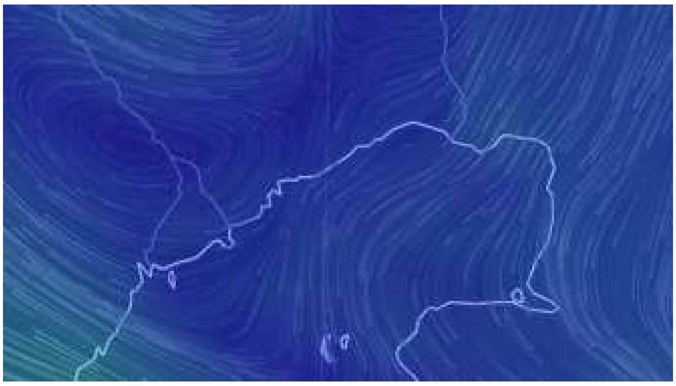


FIGURE 4. Map of the wind direction of the Northern part of the Caspian Sea.

Position/Form. The feather shape shown in Fig. 5 is a consequence of the fact that the wind captures the heavier components of the oil film more strongly and these components are moved faster by the wind than the lighter ones. In the image, the heavy components of the oily products on the leeward side of the mineral oil films have clear boundaries. Oil from natural leaks or from oil platforms can be detected using time series radar images.

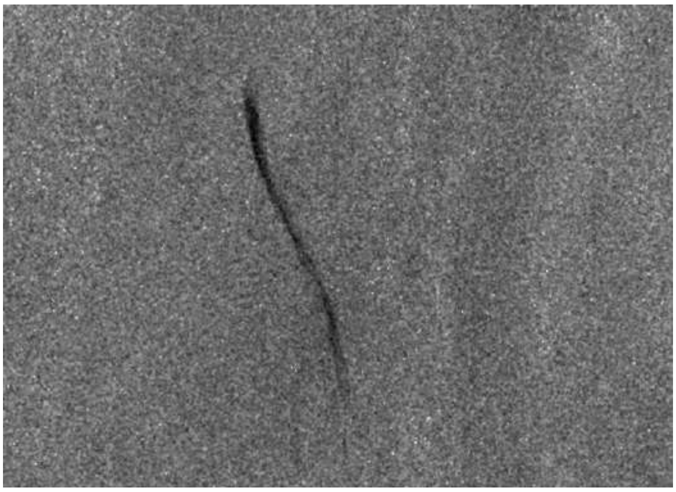


FIGURE 5. A form with feathers of an oil slick.

Radar reflection. The satellite's radar image works by reflecting radio waves from the Earth's surface and receiving the signal back. Radio waves are measured on a scale of dividing frequencies by decibels (Fig. 6), which determines the degree of signal absorption in the image. The signal frequency value determines the origin of a spot/discharge/leak:[17]

• oil (mineral oil) and oil-containing products have a difference of 3dB less than the total background (average) in the image;

• upwelling - the rise of deep waters to the surface. The difference is 7dB more or less than the total background (average) in the image;

• turbulent water from ships or internal currents is 11/12dB (average) in the image, and sand banks on the coast vary in the region of 10dB.

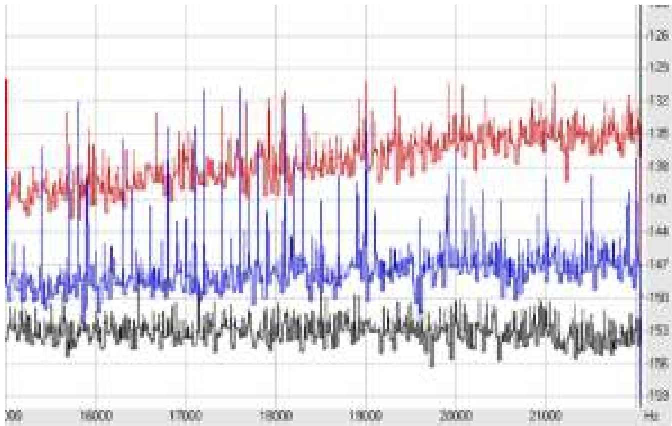


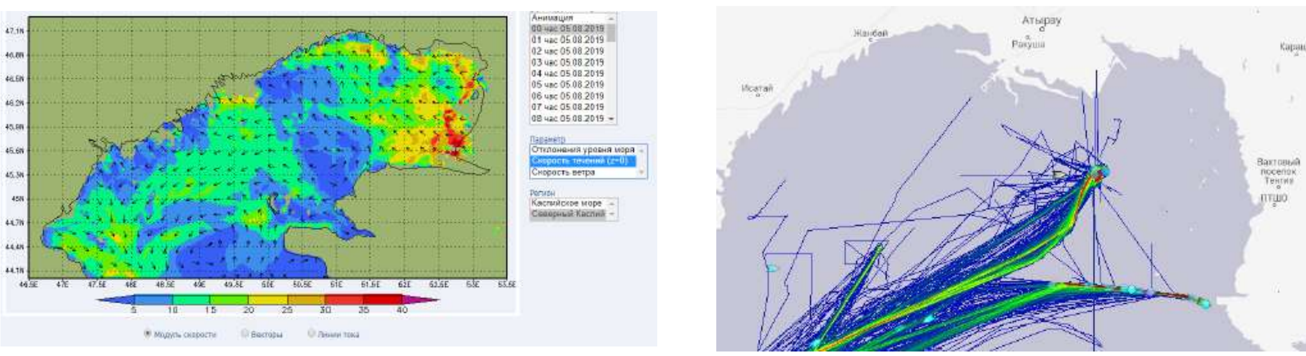
FIGURE 6. Scale for dividing frequencies by decibels.

Additional resources for expert analysis. When identifying oil pollution, the following factors are considered:
• location of oil platforms, terminals;
• sea surface relief;
• wind field of the sea surface;
• surface current direction;
• ship routes;
• weather conditions, etc.

It is necessary to pay attention to the direction of currents, temperature, as well as the strength and direction of the wind. There are open data sources that provide access to such information.[18]

The "Operational module "Yoshimo" (Fig. 7a) provides access to the service, which indicates the hourly forecast of wind and currents, as well as sea temperature.[19]

The "Marine traffic" resource (Fig. 7b) makes it possible to track and analyze the movement of vessels in real time, which allows one to compare the time and coordinates of pollution, and the direction of movement of the suspected vessel to determine the oil spill source. Analysis and identification of the most active routes of sea vessels on the territory of the Atyrau region, enable identification of anthropogenic pollution along these routes.[20]



a)"Operational module "Yoshimo"

b)Resource "Marine traffic"

FIGURE 7. Auxiliary sources of additional information.

VALIDATION OF THE DEVELOPED METHOD AND CREATION OF A DIGITAL MAP.

Testing the Method.

Over the period of satellite observations on the territory of the KSCM within the Atyrau region, more than 120 satellite images were analyzed, with a total area of more than 5.5 million km2, which at different frequencies (due to the peculiarities of each satellite) captured partially or completely the area of interest. It has been experimentally established that it takes up to four hours to process one optical image, processing of radar images takes up to six hours. As a result of the application of the Method, more than 25 facts of oil pollution were revealed and the following conclusions were drawn: 1. An analysis of the oil spills shapes showed that the main source of the sea surface pollution is moving vessels, which leave narrow spots of an extended shape. The vast majority of anthropogenic pollution of the sea surface detected on satellite images of the KSCM within the Atyrau region are oil-containing films caused by discharges of water containing oil products from ships. The main components of pollution from ships are oil-containing flushing, ballast, and bilge water from the premises of cargo pumps. 2. It was established that in the northern part of the Caspian Sea there are no locations with a constant concentration of oil spills on a regular basis. 3. The average area of one oil slick was determined, which ranged from 80000 m2 to 100000 m2, the total area being more than 1.9 million m2. 4. The seasonal variability of the number of oil spots and their total area, which is associated with the seasonal variability of the winds in the study area, is determined. In the autumn-winter period, there are certain difficulties in detecting oil spills on radar and optical images due to storm conditions.

Collection and transportation of water samples from identified oil pollution areas for subsequent laboratory analysis.

The research plan for 2019 included at least two trips. Departure to oil pollution sites was carried out no later than 48 hours from the receipt of the request. Departure coordinates were given at the time of requests. The task at the study sites is sampling from the oil pollution area of the Caspian Sea:

- sampling from the surface and the "average" water column (3 samples within a radius of 50 meters from the coordinate) for subsequent laboratory determination of the presence of oil and oil products.

- sampling from the surface and the "average" water column at 2 points (within a radius of one kilometer from the coordinate) in order to confirm the content of oil and oil products near the coordinate.

Sampling of the sea water in the identified oil pollution areas was carried out on August 20 and 31, 2019 (Figure 8).

The average concentration of oil products in the surface water horizon in the identified areas of oily water exceeded the maximum permissible concentration of oily substances for water bodies from 224.3 to 897.4 times accordant with the class of water use.[21]

The observed differences in the concentration of petroleum products (August 20 and 31, 2019) in the selected samples can be explained both by the sampling time frame (from detection of the slick to the arrival of the research vessel) and environmental conditions (excitement, temperature, etc.). According to the results of geospatial analysis in 2011, the majority of film pollution in the Russian and Kazakh sectors of the Caspian Sea were grouped along shipping routes leading to the Astrakhan and Caspian canals, on approaches to the ports of Aktau, Atyrau and Makhachkala, where a large concentration of ships was observed.[22]

The high content of naphthalene, acenaphthene, phenanthrene, fluorene in the first slick area suggests the natural origin of sea water pollution caused by the flow of oil hydrocarbons from the seabed in the form of a gas-oil mixture (periodic discharges through cracks in the Earth's crust), or the transfer of a spot by currents from nearby oil fields (for example, during exploratory drilling).

Low hydrocarbon concentrations in the region of the second slick in samples from a depth of up to 2 meters are probably caused by mixing of the surface water layer by vortex flows of ship propellers. It can be assumed that hydrocarbons could get into ballast or household water, which could be discharged during the ballasting of the vessel, before the forthcoming call to the port.

FIGURE 8. Sampling for laboratory analysis.

Creation of a digital map of "oil pollution facts in the KSCS water area within the Atyrau region."

In information-analytical control systems, digital maps must provide a real-time assessment of the situation, solve problems and organize interaction, study the geographical features of the monitoring object, and also perform the necessary calculations when assessing the situation, modeling actions, predicting changes, determining the coordinates of objects on the ground.[23]

Creating a map based on radar and optical images allows one to specifically visualize the magnitude of the consequences and make an unbiassed decision in the events of oil and oil products spilling.

Thus, in the study "Analysis of oil pollution of the Kazakhstan sector of the Caspian Sea within the Atyrau region based on the use of Earth remote sensing data and geographic information systems", a Map was created on the basis of QGIS software (Fig. 9). The map acts as:

• systems for providing operational information on the facts of the leak of oil and oil products on the territory of KSCS within the Atyrau region;

• archival database for analysis of identified contaminants;

• archive of satellite images of the Earth from satellites with radar and/or optical apertures.

The map not only provides quick access to the analysis data on the ecological state of the KSCS water area within the Atyrau region, but also provides the opportunity to receive information data to specialists outside the field of remote sensing and GIS.

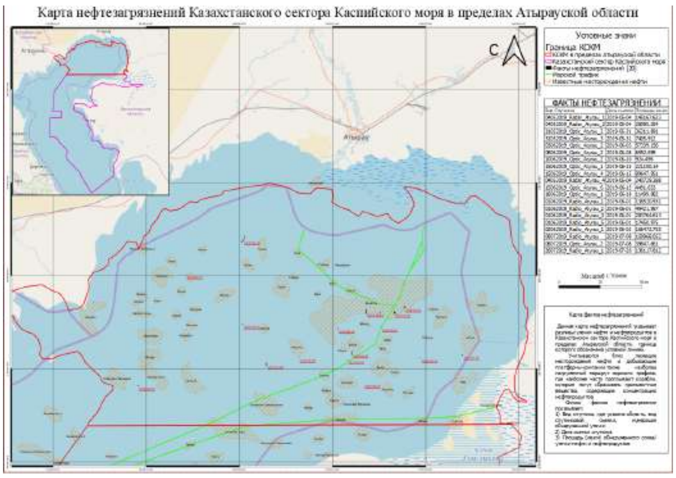


FIGURE 9. Map of the facts of oil pollution of the KSCS within the Atyrau region.

CONCLUSIONS

1) Modern methods of space monitoring of oil pollution of the seas and inland waters was analysed. Information on oil pollution of the KSCS water area within the Atyrau region was collected.

2) The new Method for space monitoring of oil pollution on the sea surface using the example of the Caspian Sea within the Atyrau region has been developed and tested. A stepwise cycle of actions has been designed to obtain and process satellite images, which allows one to detect and identify oil pollution in the Caspian Sea.

3) "The map of KSCS oil pollution facts within the Atyrau region" has been created. Field studies of oil pollution sites identified during the testing of the Method were carried out. According to the results of laboratory analyses, oil-containing substances have been found in the water samples.

4) As a final stage of the project material and technical support was provided in the form of computers with specialized software for monitoring of oil pollution. In addition, the training course was conducted for the representatives of the "Situational Center" of Atyrau region. The main economic and social effects of the study are as follows:

• the data obtained allow one timely and effectively coordinate actions aimed at eliminating the effects of oil pollution, environmental protection, as well as the rational use of natural resources.

• timely collection of information and analysis of the situation allows one to warn in advance of dangerous natural and man-made phenomena, which prevents casualties and reduces damage.

• continuous and unbiased monitoring of oil pollution at KSCS encourages subsoil users to comply with the standards for oil production and transportation of oil products.

• the method will allow one to get reliable identification and analysis of oil pollution, which will significantly save time and labor when making decisions and developing measures.

DIRECTIONS FOR FUTURE RESEARCH.

The systems for monitoring the state of the environment and its resources that exist today in the Caspian region require improvement. Most state and non-state organizations and companies in the region systematically or occasionally monitor various environmental parameters. This information is collected in the information resources of organizations and companies and are not interconnected. These observations are scattered both in time and in space and do not have a single methodological basis.

Accordingly, in the region there is no regional interdepartmental structure for the collection, assessment and analysis of environmental monitoring results, which does not allow one to see the general picture of the state of the natural environment in the KSCS water area and the coast within the Atyrau and Mangistau regions.

For this purpose, on July 29, 2018, the LLP "The Caspian Regional Center for Monitoring of the Environment and Emergencies" was created, the founders are the Caspian Research Institute of the International Scientific Complex Astana, JSC Kazakhstan NC "Garysh Sapary", and the LLP "Kazakhstan Agency of Applied Ecology".

Also, on September 19, 2018, a Consortium was created with the participation of the LLP "The Caspian Regional Center for Monitoring of the Environment and Emergencies", the Caspian Research Institute of the International Scientific Complex Astana, JSC NK Kazakhstan Garysh Sapary, the LLP "Kazakhstan Agency for Applied Ecology" and RSE "Kazhydromet". The purpose of the Consortium is to create a unified system for monitoring the environment and emergencies in the Caspian region of Kazakhstan throughout the KSCS water area and the territory of Atyrau and Mangistau regions.

The consortium may become an interdepartmental structure to create a unified system for monitoring the environment and emergencies in the Caspian region of Kazakhstan. The scientific potential of the Consortium and the Caspian Regional Center for Monitoring of the Environment and Emergencies would enable to conduct large-scale research work on the creation and operation of a regional integrated monitoring system, including space monitoring of the condition, identification of anthropogenic impact of oil and other pollution in the KSCM using GIS and remote sensing, modern research methods and information processing.

The developed Method has shown its effectiveness in detecting and predicting the spread of oil pollution, taking into account the features of the Northern Caspian, such as shallow water, temperature and water circulation. In the future, we plan to conduct a similar study within the Mangistau region and to develop a methodology, which will take into account the morphometric features of this region, the regularity of shipping routes and the number of offshore platforms for the extraction of natural resources. The experience gained on the basis of the Atyrau and Mangistau sectors of the Caspian Sea will serve as the basis for the detection and timely response to oil and oil products spills in the water area of the Kazakhstan sector of the Caspian Sea.

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Development of the web atlas of Kyzylorda region

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This article presents the experience of creating a web atlas of Kyzylorda region using GIS technologies. The developed web atlas is a cartographic work of a new generation published in Internet, which is a system of interconnected web maps with illustrative and descriptive material. The implementation of this project is based on the use of an interactive cartographic database developed within the framework of the project on natural conditions, socio-economic development and the ecological state of the natural and economic systems of Kyzylorda region. The article describes the main approaches and methods related to the development and creation of the Atlas: conceptual framework, structure, implementation stages and General characteristics. The created Atlas is intended for a wide range of users and can be considered as an information system that contributes to the accumulation of scientific knowledge, its display, analysis and updating. The methodological basis for implementing the Atlas can be used to conduct similar research in other regions of Kazakhstan.

Keywords: Kyzylorda region, web atlas, thematic map, web mapping, interactive map.

INTRODUCTION

According to one of the most common definitions, "Atlas is a systematic collection of maps made according to a single program as a complete work and published as a book or set of sheets, a system of interconnected and mutually complementary maps" [1]. Atlases in the information environment are a separate, multidimensional form of representation of geographical features of territories, which allows us to consider them as a state resource for managing territories. At the same time, atlases reflect the level of geographical knowledge and increase the level of geographical knowledge of the population. [2].

The ancestor of geographical atlases creation is considered to be the ancient Greek scientist Claudius Ptolemy (II century ad). For that time, Ptolemy's "Geography" was an outstanding work with a collection of 27 maps (T. Svatkova, 2002). But, then and later, the works on drawing up a series of maps were not called "Atlas". The term "Atlas" appeared only in the XVI century and has Greek roots. It is associated with the name of the mythical king of Libya, who, according to legend, first made a celestial globe. The origin of the term is tied to the southern coast of the Mediterranean sea, where the Atlas mountains rise, and it was first introduced by Mercator in 1595 to refer to the maps he compiled (A. Medeu et al., 2014.). Mass production of atlases in the world has started in the middle of the XVI century. The Great geographical discoveries of the XV-XVI centuries served as a powerful impetus to the development of Atlas cartography.

The cartographic image of the territory of Kazakhstan originates from ancient times and covers about 2.5 thousand years (Gorbunov A. P., 2011, Vilesov E. N., etc., 2009). Despite the fact that different researchers and scientists created a large number of different thematic maps on the territory of the country, the development and publication of atlases, as a systematic collection of maps and a complete work, began in the mid-60s of the XX century. In 1963-1970, regional atlases were published in Kustanai region (1963), Virgin territory (1964), Karaganda region (1969), and Northern Kazakhstan (1970). Regional atlases contain 2 major sections with nature maps and socio-economic maps. In the late 1970s, Kazakh scientists, under the auspices of the geography Sector of the Kazakh Branch Of the Academy of Sciences of the USSR, compiled an Atlas of the Kazakh SSR, in which natural maps were placed in the first volume (1982), and economic maps – in the second (1985). The first cartographic system product describing the state of natural resource potential and socio-economic development of independent Kazakhstan was the "National Atlas of the Republic of Kazakhstan". It was developed and created by the Institute of Geography with the participation of leading scientists of the Republic by order of the Ministry of environmental protection of the Republic of Kazakhstan (2004-2006) and was published in a small edition in 2006. The Atlas added natural and almost completely updated thematic maps of the socio-economic content of the two-volume "Atlas of the Kazakh SSR". At the same time, for the first time in our country, the Atlas system block was created (separate 3-d volume), dedicated to the ecological state of the Republic's environment.

In 2008, the historical and geographical Atlas of Turan, containing ancient maps of the territory of Kazakhstan was published for the first time (Atlas of Turan on ancient maps, 2008). The same year "Great Atlas of history and culture of Kazakhstan" was published (Great Atlas of history and culture of Kazakhstan, 2008).

A number of major cartographic works of general and special purposes as well as references from 2010 to 2015 published by the Institute of Geography of Kazakhstan: updated and expanded "National Atlas of the Republic of Kazakhstan" (National Atlas of the Republic of Kazakhstan, 2010), created for the first time in the "Atlas of natural and technological hazards and risk of emergencies in the Republic of Kazakhstan" (Atlas of natural and technological hazards and risk of emergencies in the Republic of Kazakhstan, 2010). In connection with the need of disclosure of specifics of natural-resource and socio-economic potential of the regions of Kazakhstan initiated development and publication of regional atlases: " Atlas of Mangistau region" (Atlas of Mangystau region, 2010) and "Atlas of Atyrau region" (Atlas of Atyrau region, 2014).

In 2016-2017, as a part of the UN development Program Project "SapaPro Tech" developed and launched an Interactive electronic Atlas of Kazakhstani solar resources (http://atlassolar.kz), which provides users with information about solar insolation (radiation) indicators and tools for analysis and calculations for pre-project work, opportunities and efficiency of solar energy use (Sixth national report of the Republic of Kazakhstan, 2018). Also, the Institute of geography of the Ministry of Education and Science of Kazakhstan has developed and published atlases at the level of administrative regions of Kazakhstan: Atlases of functional zoning of the Aral, of Kazalinsky districts of Kyzylorda region and Balkhash district of Almaty region in Russian and Kazakh languages. They contain complete cartographic information about the state of ecosystems, land resources, and socio-economic potential of these areas.

The portfolio of works in the field of Atlas mapping of Kazakhstan can be attributed to being developed at the moment Atlas of Kyzylorda oblast, which is implemented by members of the International scientific complex "Astana" and the Institute of Geography of MES RK in 2018 in the framework of the project "Creation of the Atlas of Kyzylorda region and interactive electronic maps based on GIS technologies".

The main goal of this research work is to assess the natural conditions, the current level of socio-economic development and the environmental condition of the territory of Kyzylorda region on the basis of GIS technologies with the creation of an Atlas in the form of an accessible Internet resource that represents the most complete portrait of the region within a single site, with information in three languages: Kazakh, Russian and English.

RESEARCH MATERIALS AND METHODS

To create thematic maps of the Atlas, we used stock and published materials, statistical data, archives, reference and analytical, reporting materials on natural conditions, socio-economic development and the ecological state of Kyzylorda region and the development of research and design and survey organizations, data from expedition surveys, remote sensing, original maps, as well as a variety of literary, reference and cartographic domestic and foreign sources.

The structure of the information base has been developed, taking into account the thematic and territorial aspects, reflecting the natural conditions, socio-economic development and environmental status of the natural and economic systems of Kyzylorda region.

Both traditional and latest geoinformation technologies, methods for decoding digital satellite images and images from unmanned aerial vehicles, and field research methods are used in the methodological plan. Approaches and methods of traditional thematic and Atlas mapping are studied. Despite the fact that atlases, along with other cartographic works, are static and their content is outdated, they, as the most compact complex systematized source of geographical knowledge, continue to take their place in the subject of scientific research and the subject of produced cartographic products.

Atlas web mapping refers to a fairly young and actively developing area of creating and presenting sets and series of maps in the Internet environment. (I. Rotanova, N. Repin, 2013). Web cartography provides not only user (client) with the access to spatial data, but also provides the ability to create and edit maps using tools in interactive mode, providing access to remote databases in online mode, as well as targeted selection of sources, combining of thematic layers, generalization, classification, selection of image methods and graphic styles (A. Berlyant, 2005).

A systematic collection of web maps created and/or posted on the Internet forms a web Atlas.

The need to develop a web Atlas of Kyzylorda region appeared due to:

- the need to obtain a visual image of the region and local geographically distributed information for performing spatial analysis and making management decisions in the field of territory organization;

- the need to provide authorities, as well as departments and operational organizations in the field of environmental management with up-to-date natural resource information for the region to effectively solve environmental problems, including the use of geo-information and web products;

- features of the current level of geoinformation and Internet technologies. Web Atlas of Kyzylorda region is a comprehensive scientific reference cartographic work designed to give a holistic view of the nature, population, economy, ecology, history and culture of the region. The Atlas is a collection of scientifically processed and mutually agreed space-time information.

The Atlas as an integral result of the analysis of modern natural conditions and resources, economy and population of Kyzylorda region in their interrelations is both a scientific work and an educational and reference resource for popularizing geographical knowledge and scientific support for sustainable development of the region.

The Atlas includes a total of 203 maps in three main areas: "Natural conditions and resources", "Environmental ecology" and "Socio-economical development".

The Atlas of Kyzylorda region was developed for the first time as an electronic geo-information resource available via the Internet. Its main advantage is that, unlike paper maps and atlases, which are becoming obsolete, the electronic version can be systematically updated. Unlike a paper (analog) map, an electronic map contains a large block of information that can be used as needed.

One of the main advantages that distinguish a web Atlas from a paper one is the constant ability to make corrections, additions, and updates that do not require a lot of resources.

Electronic maps have many additional and useful properties. Information in the electronic map is presented in the form of thematic layers. For example, a single layer of the electronic map can contain information about rivers, the second on human settlements, the third - about natural phenomena, etc. Each layer can be viewed separately, to combine several layers or you can select individual information from different layers and display it on the map. Popular map resources are used as a map substrate.

A web Atlas can be defined as a collection of systematically arranged topographical and thematic layers. Layers create maps which are organized by the division management system and are intended for publication in digital format using information technology. The process of developing a web Atlas is more complicated than a printed one.

It was with the advertisement of electronic maps that the term "geographic information systems" (GIS) appeared. The definition of GIS is based on the concept of DBMS (database management systems) designed to work with geographically-oriented information. With it, the visualization of the maps themselves can be easily supplemented with explanatory texts, tables, graphs, charts, photos, and other tools.

As a part of the project on creation of the Atlas of Kyzylorda region, based on the use of these advanced GIS technologies, vector topographic bases for digital thematic maps were compiled. Using actual space images and pictures from the UAV, developed the optimal range of scale maps in the Atlas: maps for the entire region – defined scale 1:1 500 000, maps of key areas – scale 1:500 000.

RESULTS AND DISCUSSION

As a result of data analysis and systematization in 2018, 78 digital thematic maps on natural conditions and natural resources of the region were compiled using the geo-information program ArcGIS 10.5. In 2019, 55 maps were compiled on the ecological state of the natural and economic systems of Kyzylorda region using the latest achievements of thematic mapping, GIS technologies, various satellite images such as Modis, Landsat, Sentinel and remote sensing methods. In 2020, 70 digital thematic maps were compiled to assess the socio-economic development of Kyzylorda region and an interactive version of the Atlas was prepared.

The development of the Atlas involved experts from specialized institutes such as the Institute of Geography MES RK, Institute of Zoology, Institute of Soil science, Institute of Hydrogeology, Institute of Botanics and Phytointroduction, Kazakh National University named Al-Farabi, LLP "ECOservice-S" and others.

Thematic maps are generally accompanied by up-to-date tabular materials, diagrams, and photos that provide a more complete understanding of the situation and expand visualization capabilities.

The use of vector maps in the Atlas, which have an undeniable advantage over raster maps, made it possible to combine the themes of similar, related maps and make their compositions. The electronic version provides a more user-friendly and interactive work, providing the possibility of switching on and off thematic layers of the map.

Structurally, the web atlas of the Kyzylorda region consists of 4 thematic sections, which, in turn, are divided into smaller components (subsections), consisting of cartographic, text and illustrative materials that consistently reveal the features of natural conditions and resources, the level of socio-economic development and the ecological state of the region.

The introductory section includes 12 maps that display the geographical location of Kyzylorda region, the view from space, physical and geographical characteristics, and the administrative and territorial division of the region. The section also includes satellite images and digital models of administrative regions, which significantly Supplement the cartographic information.

The section "Natural conditions and resources" is designed to study natural conditions and resources for their rational use and contains 66 thematic maps, which are grouped into seven subsections:

1. Tectonics, geological structure and relief
2. Climate, agro-climatic resources
3. Underground and surface water
4. Soils
5. Vegetation
6. Wildlife
7. Landscapes

Maps of this section characterize geophysical conditions, tectonics, seismicity, geological structure, terrain, minerals, climate, agro-climatic and land resources, surface and underground waters, soil cover, flora and fauna of Kyzylorda region. In the synthesized form, the features of the complex and diverse nature of the region are presented in the form of maps of landscapes and physical and geographical zoning, which show more than 20 natural and territorial complexes.

These maps are important for management and life support of the population, because they allow to take into account the problems of the natural environment – reducing the level of the Aral sea, desertification of the territory, salinization, impoverishment of the animal world, the drastic change of marine biology, the deterioration of natural vegetation and others.

Section "Ecology of the environment" is devoted to the topic of formation of the ecological situation in Kyzylorda region and includes 55 thematic maps grouped into the following subsections by thematic content:

1. Factors of anthropogenic impact on the natural environment
2. Ecological state of natural systems
3. Ecology and public health
4. Desertification
5. Nature protection
6. Environmental safety and sustainable development

The section begins with a series of maps, the main object of the image on which are factors of anthropogenic impact on the environment and pollution of the air basin. The most representative and extensive information contained on the maps was the subsection "Ecological state of natural systems", consisting of 21 maps. These maps show the state of radioecological tension, pollution of underground and surface waters, the ecological state of water bodies, areas at risk of exposure to biological hazards, the ecological state of agricultural land, landscapes, cultural and technical state of pastures and haymaking, seismic and meteorological hazards, soil erosion and deflation, aeolic, soric, erosion processes, and the exposure of settlements to dangerous natural processes, results of zoning of the territory according to the conditions of water supply by underground drinking water and geo-ecological zoning, distribution of acclimatized and reacclimatized species of mammals and birds, as well as mammals that have epizootological and epidemiological significance.

The logical continuation of the collection of thematic maps is the Atlas subsections, which include maps that provide information on the incidence of various diseases, natural and anthropogenic factors of desertification, rare and endangered species of flora and fauna, protected areas, environmental projects and activities. The last block of the section includes maps for environmental safety on Wednesdays-air, water, and land.

The third section "Socio-economic development" includes 70 maps grouped into the following subsections:

1. Demographics and migration
2. Social sphere
3. Industry
4. Transport and engineering networks
5. Agricultural industry
6. History and archaeology
7. Tourism and recreation
8. Functional zoning
9. Economy

The above maps show the number and density of the population, gender and age composition, employment and income of the population, the state of culture, education and health, all types of industry, agriculture and transport, tourism opportunities and foreign economic relations. The economy and social sphere of administrative districts and city administrations, history and archeology, and the state of modern land use are considered separately.

According to the Statistics committee of the Republic of Kazakhstan, the territory of Kyzylorda region as of

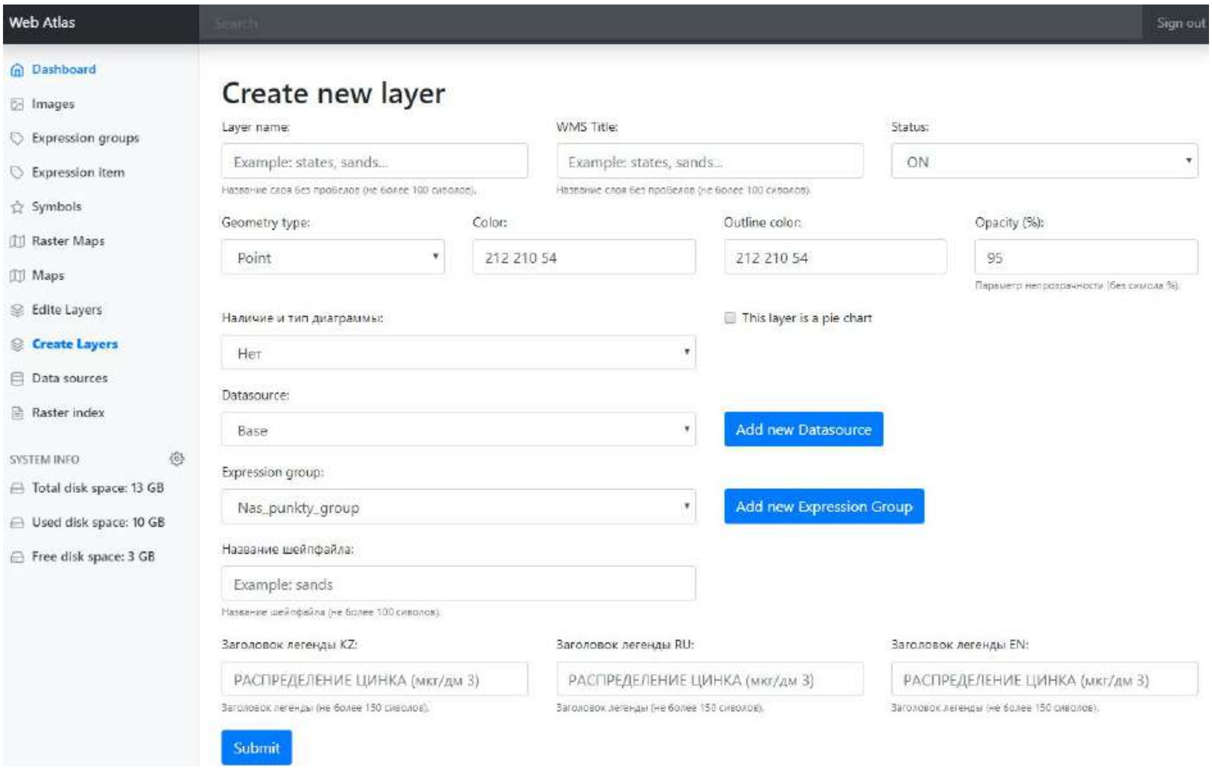

FIGURE 1. Web interface for creating a new layer The interface is designed to be intuitive and has an explicit logical chain for creating layers and adding them to maps.

January, 1, 2020 is 226.0 thousand km^2. It occupies the 4^{th} among 14 regions of Kazakhstan by area and occupies 8.3% of the Republic's area. The population is 803,545 people, or 4.3% of the population of the Republic, including 358,131 people (44.6%) living in urban areas, and 445,414 people (55.4%) living in rural areas. The average population density in the oblast is 3.5 people per km^2. The oblast has 142 rural districts, 4 cities, 2 villages and 232 rural localities within 7 administrative districts and the city of Kyzylorda.

The work uses the ArcGIS 10.5, ENVI 5.3 software tools, the MapServer map server, and Landsat, Sentinel satellite images, as well as images from SasPlanet and Google Earth resources.

A web version of the Atlas was created to provide access to all interested users to thematic maps of Kyzylorda region Atlas via the Internet. An intuitive web interface of the site containing GIS services, information search and analytical services has been developed. Raster and vector versions of the prepared thematic maps of Kyzylorda region are uploaded to the web server after passing the technical revision.

In comparison with the tasks, the solution of which is guided a paper version of the Atlas region, the electronic version of the Atlas with data collected in this multidimensional data, information and knowledge, significantly increase the importance and role of the product prototype as a necessary component of information technology infrastructure not only in education but also in the development of the regional economy, because it provides production, development of solutions and ways of implementation of the tasks of territorial planning and development (N. Filatov 2014).

Creating an electronic version of Kyzylorda region Atlas significantly increases the ability to access thematic information, and allows you to quickly update data on maps.

The web Atlas implements the function of differentiation of access rights for different groups of users, which provides separation of editing rights for spatial and attribute information directly in the web interface of the geoportal.

The web interface for working with interactive maps is divided into two parts. The first part is responsible for working with interactive maps in administration and editing mode. It provides functionality for creating categories, tables, and maps. You can delete and modify existing data. In the second part of the interface, users work with interactive maps. With the ability to work with public functionality in read-only mode.

To create new map layers, a specialized interface has been developed that allows you to interactively create new layers. It is used to upload a file or submit a completed web form. Figure 1 illustrates the appearance of this interface.

Figure 2 shows a fragment of the interactive maps web interface. A web page consists of several blocks. The first

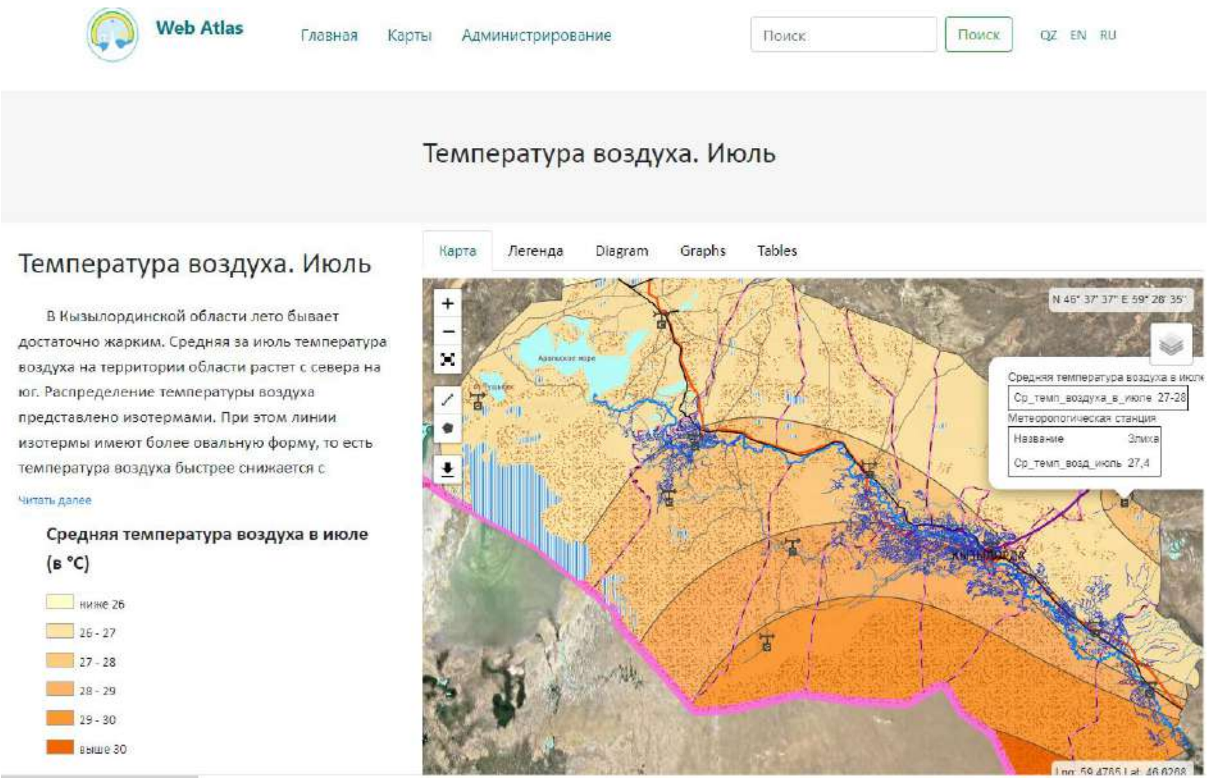

FIGURE 2. Web interface for interactive maps.

block contains the main menu of the site, where the user can choose the functionality that interests him, switch the language settings of the site, as well as a search bar for finding the maps that he needs. The second block contains a menu of map categories, which allows you to select the category of maps that the user is interested in. The third block contains a list of maps.

The interface for viewing interactive maps has been developed (figure 3). The user interface is a composition of four blocks: the menu block at the top of the site, the block with the map legend (criteria), the map interaction block, and the menu at the bottom of the page. The block with the site legend is filled in automatically based on the thematic layers that are attached to this map

The main block of this interface is the interaction block with the map and includes 5 tabs: "Map", "Legend", "Charts plotting", "Graphs plotting", "Tables". In the "Map" tab, an interactive map is presented. when you click on it, a window with attribute information about this object pops up. This tab has functionality for enabling and disabling layers, which allows you to view only the layers of interest to the user. The Legend tab contains additional information about the map that the author can place in the legend.

In the "Charts plotting " tab, a pie chart is built using the corresponding attribute table. The number of selected columns in the associated attribute table determines the number of pie chart sectors, and the selected rows are added together. This module is developed in JavaScript using the JQuery library, as well as ChartJS.

The "Graphs plotting" tab (figure 4) allows you to plot graphs based on the selected attribute table. The user must select the attribute table that interests them, the column for the abscissa axis, and which columns the graphs are needed for.

The Tables tab is used for viewing and copying attribute information. The web Atlas help system explains the General use of the Atlas.

You can make lists with automatic numbering . . .

CONCLUSIONS

The main conceptual line of creating the Atlas was a comprehensive study, assessment and mapping of the region's territory as the main prerequisites and key elements of its sustainable development. All Atlas thematic maps are accompanied by geographical descriptions, explanatory texts, photographs, diagrams and tables.

The method of drawing up maps of the Atlas is aimed at reflecting the most plausible distribution of each phenomenon across the territory and showing the chains of natural and socio-economic relations.

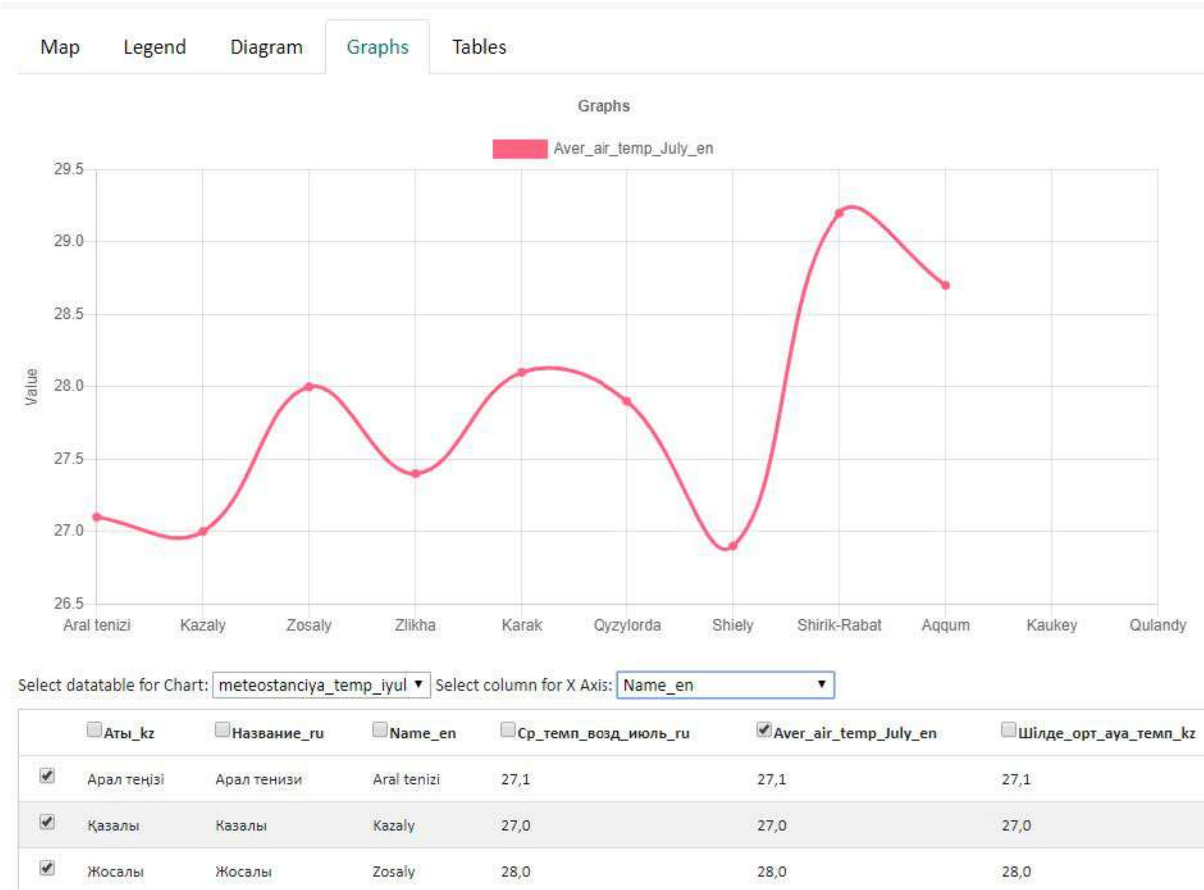

FIGURE 3. Web interface of the charting module.

Atlas of Kyzylorda region and interactive electronic maps are designed for comprehensive study, assessment and management of the territory, in-depth scientific research, drawing up plans for rational nature management and forecasting the consequences of human intervention in the environment, designing environmental protection measures, improving the socio-economic and environmental situation.

The development of a web Atlas of Kyzylorda region that reflects the natural resource potential, socio-economic development and ecological state of the natural and economic systems of Kyzylorda region and allows working with it in an interactive mode is an important stage of geographical research of the region. Implementation of the technology for creating a web Atlas that works with graphic, attribute, statistical, text, illustrative and any other information in remote user mode, and its subsequent deployment in various structures of the region is very relevant and promising.

The developed web atlas of Kyzylorda region allows:

- provide multi-user access to spatial and attribute information on the Atlas map through a single mapping web interface (geo-information portal) with navigation and zoom capabilities;
- display thematic maps of the Atlas and get detailed information about objects and phenomena displayed on the map, including additional information (notes, tables, graphs, charts, photos, videos, links to another site, etc.);
- search for objects by name and coordinates, displaying the results found on the map and providing information on them.
- calculate geometric characteristics (areas, lengths, coordinates) of objects;
- upload the maps in the form of bitmap formats.

The introduction of interactive electronic maps will provide:

- centralized storage of large amounts of information;
- quick access to the information available in the database for different levels of systematization according to the user's regulated requests;
- presentation of information in convenient and user-friendly forms (cartographic, tabular, illustrative);
- information basis for solving various applied tasks in the future for forecasting and modeling the environmental situation and socio-economic consequences of man-made impacts in the oblast.

The Atlas is focused on scientific and informational support of practical solutions and actions for the development of the region. The Atlas is based on detailed, up-to-date, reliable and accurate knowledge and materials.

Thus, the created Atlas and interactive maps allow all interested users to quickly get comprehensive cartographic and thematic data for the region. You do not need to install specialized software or update your computer hardware.

Users have the ability to visualize thematic map data and manage map content, such as navigating and switching between sections, sub-sections of the Atlas and maps of different subjects, enabling or disabling individual layers, viewing map and attribute information, visualizing charts, graphs and tables, getting coordinates of objects and measuring the distance between them, and areas, printing maps and attribute information.

The data published in the web Atlas is available to all categories of users - both for government employees and for individuals and legal entities. The materials obtained during the creation of the interactive Atlas and the information resource itself can be used by: research and educational organizations, state and Executive authorities, commercial structures in the process of developing tourist routes, concepts and strategic plans for the development of tourism, as well as in the process of involving objects, routes and projects of domestic tourism in the economic turnover of the region.

The target audience of the Internet portal of the Atlas: a wide range of users-administrative and management structures, business structures, public organizations, specialists in various fields, scientists, teachers, postgraduates, students, teachers and schoolchildren, as well as all citizens of Kazakhstan and foreigners interested in obtaining high-quality diverse information about natural conditions, economic development and the ecological state of Kyzylorda region.

Atlas of Kyzylorda region is a complex set of information of a complicated multi-level and multi-functional system that includes the collection and systematization of information, identification of development trends, forecasting of situations, planning and management of natural and economic systems.

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