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Р. Жаналиева, Б. Имангалиева, Б. Торсыкбаева, Н. Ескараев, Н. Убайдулаева, Н. Сұлтанов <i>Ceratiodes latens</i> сұр терескендердің химиялық қасиеттерін зерттеу.....	
Р. Жаналиева, Б. Имангалиева, Б. Торсыкбаева, Н. Ескараев, Н. Убайдулаева, Н. Сұлтанов <i>Изучение химических свойств серых терескенов ceratoides latens</i>	
R. Zhanaliyeva, B. Imangaliyeva, B. Torsykbaeva, N. Yeskaraev, N. Ubaidulayeva, N. Sultanov <i>The study of the chemical properties of gray tereskenes ceratoides latens.....</i>	10
И.В. Корольков, А.Р. Сулейманова, И.Б. Муслимова, М.В. Здоровец <i>Тікелей осмоста қолдану үшін полиэтилентерефталатты тректік мембраналардың тотығуы</i>	
И.В. Корольков, А.Р. Сулейманова, И.Б. Муслимова, М.В. Здоровец <i>Окисление полиэтилентерефталатных трековых мембран для применения в прямом осмосе</i>	
I.V. Korolkov, A.R. Suleimanova, I.B. Muslimova, M.V. Zdorovets <i>Oxidation of poly(ethylene terephthalate) track-etched membranes for use in direct osmosis.....</i>	24
Т.Т. Машан, О.М. Жолымбаев, Н.Б.. Қазанғапова, Д.Р. Онтағарова, Е.Т. Әбілмәжінов, А.Ж. Құрманғожинов, Б.Ш. Ганиев <i>Жол жабынының құрылымдық қабаттарында жүн және мұнай қалдықтарын геотордың толтырғышы ретінде пайдалану (шолу).....</i>	
Т.Т. Машан, О.М. Жолымбаев, Н.Б.. Казанғапова, Д.Р. Онтағарова, Е.Т. Абилмажинов, А.Ж. Курманғожинов, Б.Ш. Ганиев <i>Использование отходов шерсти и нефтепродуктов в качестве наполнителя георешеток в конструктивных слоях дорожного покрытия (обзор).....</i>	
T.T. Mashan, O.M. Zholymbayev, N.B. Kazangarova, D.R. Ontagarova, E.T. Abilmazhinov, A.Zh. Kurmangozhinov, B.Sh. Ganiev <i>The use of waste wool and petroleum products as a filler for geogrids in the structural layers of the road surface (review).....</i>	38
В.Н. Фомин, С.К. Алдабергенова, Н.К. Келесбек, Д.А. Кайкенов, М.А. Туровец <i>LIBS және хемометрикань қолданып кварцты жіктеу және сандық талдау әдісі.....</i>	
В.Н. Фомин, С.К. Алдабергенова, Н.К. Келесбек, Д.А. Кайкенов, М.А. Туровец <i>Метод классификационного и количественного анализа жильного кварца с применением LIBS и хемометрики.....</i>	
V.N. Fomin, S.K. Aldabergenova, N.K. Kelesbek, D.A. Kaikenov, M.A. Turovets <i>Method of classification and quantitative analysis of vein quartz using LIBS and chemometric techniques.</i>	48
О. Каргал <i>Навигация в будущее химии: приоритеты и возможности для устойчивых инноваций (обзор)</i>	
О. Каргал <i>Химия болашағын бағдарлау: тұрақты инновацияның басымдықтары мен мүмкіндіктері (шолу)</i>	
O. Kartal <i>Navigating the Future of Chemistry: Priorities and Opportunities for Sustainable Innovation (review)</i>	61

М.М. Өвезов

Өзбекстандағы тау мұздықтары атауларының қалыптасуының табиғи географиялық негіздері және гляционимдер транскрипциясы мәселелері (Пскем алабының гляционимдери мысалы).....

М.М. Аvezov

Физико-географические основы формирования названий горных ледников Узбекистана и проблемы транскрипции гляционимов (на примере гляционимов бассейна Пскем).....

M.M. Avezov

Physical geographical basis for the formation of the names of mountain glaciers in Uzbekistan and the problem of transcription of glacionyms (using the example of glacionyms of the Piskom basin)...

81

Л.Х. Акбаева, Н.С. Мамытова, Е.Ж. Макажанов, Н.Ж. Жакешов

Тау-кен қалдықтарын басқарудағы экологиялық оқиғалар.....

Л.Х. Акбаева, Н.С. Мамытова, Е.Ж. Макажанов, Н.Ж. Жакешов

Экологические происшествия при управлении отходами горнодобывающей промышленности

L. Akbayeva, N. Mamytova, Y. Makazhanov, N. Zhakeshov

Environmental incidents in mining waste management.....

92

Емин Атасой, Хакан Онал

Дамушы жаңа туристік бағыт: Масбате провинциясының географиялық ресурстары мен туристік әлеуеті (Филиппин Республикасы).....

Емин Атасой, Хакан Онал

Развивающееся новое туристическое направление: географические ресурсы и туристический потенциал провинции Масбате (Республика Филиппины).....

Emin Atasoy, Hakan Onal

An Emerging New Tourism Destination: Geographic Resources and Tourism Potential of the Province of Masbate (Republic of the Philippines).....

107

С.Б. Бисенбаева, Ш.М. Мелисбек, Е.Қ. Баймұқан

Жерді бақылау негізінде Қазақстандағы орман мониторингіне шолу.....

С.Б. Бисенбаева, Ш.М. Мелисбек, Е.Қ. Баймұқан

Обзор мониторинга лесов в Казахстане на основе наблюдения за Землей.....

S. Bissenbayeva, Sh. Melysbek, E. Baimukan

An overview of forest monitoring in Kazakhstan based on Earth observation.....

135

Ж. Рахымжан, А.Д. Рахешева, З.Ж. Нурғалиева, Р.М. Тазитдинова,

М.Ж. Мирзабекова, Н.С. Ергазина

Қазақстан аумағындағы тұзданған жерлердің экологиялық жағдайын бағалау.....

Ж. Рахымжан, А.Д. Рахешева, З.Ж. Нурғалиева, Р.М. Тазитдинова,

М.Ж. Мирзабекова, Н.С. Ергазина

Оценка экологического состояния засоленных почв на территории Казахстана.....

Zh. Rakhymzhan, A.D. Rakhisheva, Z.Zh. Nurgaliyeva, R.M. Tazitdinova,

M.Zh. Mirzabekova*, N.S. Ergazina

Assessment of the ecological state of salinized lands on the territory of Kazakhstan.....

150



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Scientific article

The study of the chemical properties of gray tereskenes *ceratoides latens*

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Abstract. Today, perennial plants of the natural flora are a raw material resource for the production of drought-resistant and heat-resistant feeds, among which *Eurotia ceratoides* occupies a special place.

In this work, the chemical properties of *Eurotia ceratoides latens* (J.F. Gmel) were studied, and the humus content in the soil was determined. The chemical and physico-chemical properties of the light gray soil (humus, water, carbonate ions and nitrogen) were revealed. The humus content was determined based on the oxidation of organic carbon with chromic acid to carbon dioxide.

The chemical composition of *Eurotia ceratoides latens* was analyzed to determine the content of nutrients (protein, fiber, fat, nitrogen-free extractables, ash) and water-soluble substances (C, CO₂, Ca, Mg) in the plant. The study revealed that the ash content in the plants remained relatively constant throughout the growth cycle, with minimal variation across different age groups. The ash content ranged from 9.11% to 10.05%, while the calcium content was found to be within the range of 3.67% to 4.90%. The content of crude fiber was determined using the Soxhlet apparatus, while the calcium cation content in the soil was evaluated by the complexometric method. The Kjeldahl method was employed to determine crude protein, and crude fat was assessed via ether extraction. Nitrogen-free extractives in ash were quantified by precipitation with a saturated solution of ammonium oxalate, and phosphorus was determined using the colorimetric method. These analyses have elucidated the nutritional value of *Eurotia ceratoides latens*.

Keywords: Teresken, *Eurotia ceratoides latens*, *Eurotia* semi-bush, chemical properties, the soil, the Kjeldahl method, the Soxhlet apparatus, the Mohr's salt, the complexometric method, alkalinity, carbonate.

Introduction

Valuable plants are abundant in the flora of Kazakhstan and Central Asia. The disorganized use of natural pastures led to desertification in the Republic steppe and desert pastures. Among the plants suitable for improving desert and semi-desert pastures, *Eurotia ceratoides*, a perennial forage plant, occupies a special place in terms of practical significance.

This plant is resistant to drought and sulfate salinization, less resistant to sulfate-chloride, and there are tight constraints on chloride salinization: when NaCl concentration is higher than 0,2%, its effect is extremely devastating.

By photosynthetic reaction, eurotia belongs to group C4 of the plants with very low water consumption and high photosynthetic yield by the photosynthetic reaction. Nevertheless, the plants grow rapidly in spring and accumulate valuable protein-rich forage for livestock breeding.

Eurotia ceratoides latens (Figure 1) and *Eurotia eversmanniana*-*Kracheninnikovi ceratoides* (L.) (Figure 2).



Figure 1. *Eurotia ceratoides latens*



Figure 2. *Eurotia eversmanniana*

Eurotia has been characterized by enhanced productivity and excellent feed quality, which makes it possible to consider *Eurotia ceratoides latens* as a perspective species to be domesticated as a pasture feeding plant (Abdraimov and Yeskaraev, 1992; Abdraimov and Taichibekov, 2010; Shamsutdinov et al., 2009; Arkincheev and Shamsutdinov, 2013; Arkincheev and Shamsutdinov, 2015). In connection with the above, the chemical properties of the semi-shrub *Eurotia ceratoides latens* were studied in the work.

Hence, examination of the chemical and physical-chemical properties of this plant is of vital importance in the judicious cultivation and use of *Eurotia*. The chemical and instrumental methods of analysis were employed to determine these properties. The experiments were conducted to identify the chemical and physical-chemical properties of light sierozem on virgin land, plowed land, and under *Eurotia ceratoides latens*. The Kjeldahl titration-based method was used in the paper to examine the content of nitrogen in plants. The chemical composition of *Eurotia* and the content of various nutrients and water-soluble substances (C, CO₂, Ca, Mg) in the plant were analyzed. The "crude" fiber and "crude" fat content were determined using the Soxhlet apparatus, and the presence of calcium cations in the soil was estimated by the complexometric method. The chemical composition and nutritional value of *the Eurotia ceratoides latens* were established (Paramonov, 2001; Zhanaliyeva R.N., 2018; Tarasova, 2012).

The literature review has shown that the chemical composition of *Eurotia* can vary depending on the upgrowth location and other factors (Shamsutdinov and Shamsutdinov, 2012; Arkincheev,

2016). In the conditions of the desert zone in Southern Kazakhstan, the composition and nutrient density of *Eurotia* are studied poorly.

Materials and methods

Description of experiments

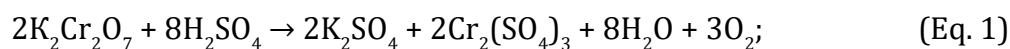
The study of the effect of the granulometric composition of the soil on the germination of seeds was carried out under laboratory conditions (GOST 25100-2011, 2015). The granulometric composition of the soil dramatically influences soil formation and agricultural use of soils. It determines water-physical, physical-mechanical, air, thermal properties, absorption capacity, accumulation of humus, the content of ash elements, and nitrogen in the soil.

The mechanical and chemical composition of the soil was determined in the soil laboratory of the Southwest Research Institute of Animal Husbandry and Crop Production.

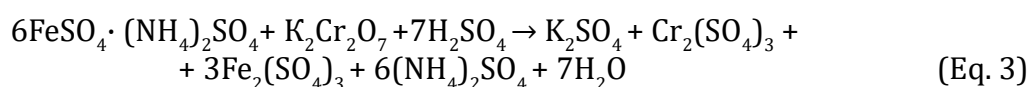
The content of crude protein was determined by the Kjeldahl method, crude fat by ether extraction in a Soxhlet apparatus, and crude fiber by the Gonneberg and Stomann methods. Nitrogen-free extractives were determined by the difference in ash after precipitating with a saturated ammonium oxalate solution, and phosphorus was analyzed by colorimetry. All calculations for chemical composition were done on an absolute dry weight basis.

A method to determine the content of humus in the soil

Following the I.V. Tyurin method (GOST 26213-91, 1989), the humus was oxidized by the chromic-sulfuric acid mixture. The $K_2Cr_2O_7$ solution at the $0,067 \text{ mol/dm}^3$ concentration served as an oxidizer. The acid reaction occurred as follows:



The chromic acid that remained after oxidizing was titrated by the Mohr's salt $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ as per the reaction



The analysis procedure. 0,2 g of the air-dry mixture was placed into a cone flask, 10,0 ml of 0,4 n-chromic anhydride in sulfuric acid was added from a burette, and 0,1 g of catalyst $AgNO_3$ was added with further mixing. The mixture was heated until it reached boiling point and boiled for about 5 minutes. After the mixture had grown cold, it was transferred to a glass with 200 ml of water. The flask was flushed out several times. Finally, the flushing water was transferred to the glass with the mixture. At this point, the water volume was approximately 300 ml. Next, 8 drops of diphenylamine were added to this solution, and then the chromic acid, which remained after humus oxidation, was titrated by the 0,2 n-Mohr's salt solution until the solution hue changed from blue to greenish.

Determination of water content in the soil

Soil moisture under *ceratoides latens* (teresken) crops was determined by taking soil samples in 3-4 replications from the following range: 0-5; 5-10; 10-20; 20-40; 40-60; 60-80 and 80-100 cm.

The sequence of procedures: A 20g batch was placed into a pre-weighted container to determine soil moisture. The selected samples were dried in drying cabinets at the temperature of 1050 °C until they reached a constant weight. Calculation:

$$\% \text{ water} = (m_1 - m_2) / m_{\text{batch}} \cdot 100\% \quad (\text{Eq. 4})$$

The Kjeldahl titration-based method of estimating the content of nitrogen

1g of the analyzed substance and 2g of catalyst (powder of 10 weight parts of cupric sulfate, 100 weight parts of potassium sulfate, and two weight parts of selenium) were added to the Kjeldahl flask, pouring in 10 cm³ of concentrated sulfuric acid. The flask contents were well stirred and heated. After decoloring the liquid, heating continued for 30 minutes. After cooling, this mineralized liquid was transferred to the distillation flask. The Kjeldahl flask was rinsed with distilled water. 20 cm³ of 4% boric acid and 5 drops from mixed indicators (0,20 g of methyl red and 0,10 g of methyl blue dissolved in 100 cm³ of a 96% solution of ethyl alcohol) were poured into the conical flask of about 300 cm³ capacity. The distillation flask was connected to the apparatus for ammonia distillation, and sodium hydroxide solution was carefully poured into the flask containing mineralized liquid through a dropping funnel. At least 3,5 cm of the sodium hydroxide solution with a weight content of 33% was to be added per cubic centimeter of sulfuric acid, remaining after the mineralization process had finished. With normal boiling, 20-30 min later, the volume of the solution in the receiving flask usually amounts to 150-200 cm³. Red litmus paper can help detect if the distillation process has been completed. To do it, litmus paper had to be placed under the flowing drops of distillate. If litmus did not turn blue, the distillation of ammonia was finished.

A method to estimate crude fiber

2g of *ceratoides latens* (teresken) were weighted in a test tube using analytical scales, then placed in a 500-ml glass. Next, 100 ml of a 4% sulfuric acid solution were poured into the glass container while being stirred. The contents of the glass were then boiled on a stove for 10 minutes, with regular mixing and the addition of hot distilled water, until the liquid reached the desired level. The glass was further cooled, and 25 ml of 30% sodium hydroxide was added to the solution. Boiling continued for 10 min, stirring and pouring in hot distilled water to the mark at regular intervals.

Then, about 200 ml of hot distilled water was added to the glass contents, letting the fiber stand to settle and pumping out the most liquid using a water injection pump. The sediment was rinsed out 2-3 times more until the alkali was completely removed (a test for red litmus). The sediment from the glass was brought to the filter, which was 10-12 cm in diameter. The filter was previously placed into containers, dried for 1-2 hours at a temperature of 100-1050 °C, and

weighed after cooling in the exicator. The sediment in the filter was rinsed out 2-3 times with hot distilled water, alcohol, and ether. The washed residue with the filter was placed in the same container, where an empty filter was dried. Ether was left to evaporate in the fume cupboard, followed by drying in the drying cabinet at 100-105 °C until its weight became constant.

The weight of crude fiber in the air-dry substance was determined by the difference in the weights of a container with a filter and fiber and a container with an empty filter.

Estimation of crude fat in the Soxhlet apparatus

The product batch of 2g in weight was brought to the dry porcelain mortar and ground with 6g of anhydrous sodium sulfate to a smooth powder. The groundmass was placed into a filter paper package and wrapped as a powder product in a drugstore. It was weighted using analytical scales and transferred to the Soxhlet apparatus extractor. Ether was poured into the receiving flask to 1/3 of its capacity, connecting it with the extractor. It was then connected to the fridge using a ground-glass neck and put into a cold water bath. Small bags with the material stood to infuse for 3-4 hours, turning on heating afterward. Ether vapors from the receiving flask entered the fridge through a wide tube, were condensed, and flowed down to the extractor, removing the fat from the material. As soon as the ether level reached the upper edge of a siphon tube, it would immediately start to overflow into the receiving flask. Fat was extracted in 5-6 hours. Then the small packages with the defatted material were withdrawn from the extractor, dried on the glass in the fume cupboard to let ether evaporate, and dried in the weighted containers at 100 to 105 °C until their weight became constant. The fat content (expressed in percentage concerning dried substance) was calculated knowing the weight of the small package before and after extraction and the weight of the empty package.

Estimation of calcium cation using the complexometric method

The primary stage of complexometric soil analysis is the titration of calcium with trilon B (disodium salt of ethylenediaminetetraacetic acid). Murexide ($C_8H_8N_6O_6H_2O$) serves as the indicator.

Soil extract preparation. A 50g batch was taken from the ground, sieved with air-dry soil, and placed into the flask (1L). Then, 500 ml of boiled distilled water was poured into it, plugged with a stopper, and shaken up for 3-5 min. The obtained suspension was filtered.

25 ml of water extract was placed into a 100 ml conical flask, and 2-5 ml of a 10% solution of NaOH and a grain of powder-like murexide indicator were added. The extract was titrated with 0,05 mol/l trilon B until a transition from pale-crimson to pale-lilac was reached. Then, the calcium ions were calculated according to Equation 5.

$$Ca^{2+} = (a \cdot 0.05 \cdot 100 K) : C \text{ (mg-equiv. of calcium per 100 g of soil)} \quad (\text{Eq.5})$$

where a is the amount of Trilon B used for titration, in milliliters;

0,05 is the normality of the Trilon solution;

K is the correction factor for the Trilon titrant;

C is the soil sample weight corresponding to the amount of extract used for titration, in grams;

Estimation of the presence of carbonate-ions in the soil

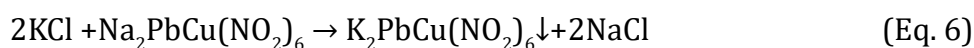
A little soil was placed into a porcelain cup, and several drops of 10% solution of hydrochloric acid were added with a pipette. Carbon oxide (IV) CO₂, formed in the course of the reaction, was released as bubbles (soil «fizzes»). The intensity of their release could infer a fairly high content of carbonates.

Microchemical analysis of the plant ash

Reactions to detect chemical elements of ash were carried out on the slides. First, a drop of the ash solution was placed on the glass slide with a blunt end of a glass rod and a drop of the appropriate reagent at the 4-5 mm distance. Next, these drops were connected with an arc-shaped channel, a proper reaction occurred, and crystals were formed.

Detection of potassium

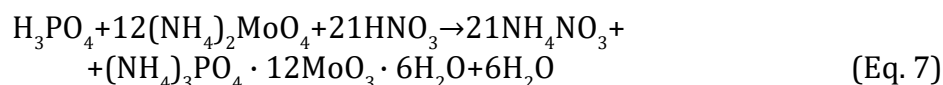
The reagent a water solution of salt Na₂PbCu(NO₂)₆. The reaction with the formation of the lead-copper nitrate of potassium occurred according to the equation:



If ash contained potassium, leaden-black and dark-brown crystals were formed.

Detection of phosphorus

The reagent a 1% solution of molybdenum-acid ammonium in the 15% solution of HNO₃. When this reagent was mixed with the ash extract, the following reaction occurred:



Greenish-yellow crystalline sediment was formed as a result of the reaction.

Results and Discussion

Results

Study carried out determining the chemical and physicochemical properties of light sierozem. An idea of the content of humus and elements of mineral nutrition is given by the data in Table 1. As a result, it was found that the content of humus at a depth of 0-5 cm (0,62) was higher in virgin soil, and at a depth of 10-15 cm (0,69) it was on the plow.

Table 1. Chemical and physico-chemical properties of light sierozem on virgin land, on plowed land, and under Eurotia ceratoides latens, 2020

Sampling location	Sampling depth (cm)	Humus	Nitrogen content	CO ₂ of carbonates	Absorbed bases		Labile forms		Absorption capacity
					Na	K	P ₂ O ₅	K ₂ O	
					Mg-equiv. per 100g of soil				
Virgin land	0-5	0.62	0.06	3.75	0.10	0.28	2.74	22.23	3.84
	10-15	0.30	0.04	4.48	0.09	0.21	1.10	23.40	3.89

Plowed land	0-5	0.32	0.04	5.04	0.01	0.23	2.64	30.42	4.04
	10-15	0.69	0.06	4.59	0.09	0.24	1.20	26.91	5.31
Under Eurotia of the 2 nd year of life	0-5	0,35	0.04	4.26	0.10	0.35	1.78	42.12	2.95
	10-15	0,60	0.06	3.64	0.09	0.24	2.06	23.40	3.00
Under Eurotia of the 3 th year of life	0-5	0.50	0.06	4.76	0.1	0.37	2.14	46.80	4.18
	10-15	0.43	0.04	4.59	0.16	0.14	1.62	21.06	3.65

The biological usefulness of pasture plants is determined by the total content of nutrients and their ratio. A review of the literature showed that the chemical composition of teresken, depending on the place of growth and other factors, can be different (Shamsutdinov, Z. S.; Shamsutdinov, N. Z. (2012); Arkincheev, D.V. (2016).

Our biochemical studies of teresken gray have shown that plants contain 10,44-27,54 crude protein, 1,62-4,05 fat, 26, 48-60,01 fiber. In plants, the ash content almost does not change either in the phases of vegetation or with the age of the plants and ranges from 9,11-10,05%, respectively, and the calcium content was at the level of 3,67-4,90. In 2021, the protein content was high, especially in the seed maturation phase. The highest fiber content was noted at the beginning of winter – 60,01% (Table 2).

Table 2. Chemical composition of *Eurotia ceratoides latens* in various years

Life year	Accounting date	Water content	Protein	Fiber	Ash	Fat	NES (nitrogen-free extractable substances)	Mineral	
2020									
Second	19.V	48.2	19.82	36.99	9.11	2,97	31.11	4.90	0.48
	30.VII	47.0	15.32	42.20	9.47	3,74	29.27	4.07	0.50
	2.X	8.5	10.55	47.33	9.48	3,04	29.60	4.60	0.31
Fourth	19.V	43.3	16.01	39.75	9.48	2.11	32.65	4.42	0.16
	30.VII	47.6	16.39	35.24	9.38	4.05	34.94	4.60	-
	22.X	27.4	10.44	48.15	9.82	2.35	29.24	3.97	0.22
2021									
Second	28.V	42.0	20.51	38.79	9.52	2.51	28.67	3.90	0.26
	15.VII	26.0	19.37	47.34	9.88	2.64	20.77	4.30	0.51
	30.IX	3.30	22.32	44.99	9.85	1.87	20.97	3.43	-
Fourth	28.V	57.2	22.42	26.48	9.39	3.11	38.60	4.08	0.28
	30.VII	30.0	24.90	-	10.05	3.28	-	3.67	0.33
	2.X	23.0	27.54	37.39	9.86	1.62	23.59	6.22	0.36
	25.XII	-	21.37	60.01	10.0	1.72	6.90	3.28	0.33

This is reflected in the nutritional value of the forage mass in winter. It is of interest to determine the content of nutrients in various plant organs: the most nutritious are leaves and seeds. Thus, the protein content in the leaves in the flowering phase is 20,06%, fat: 2,80-3,55% in the stems is only 13,22%, fiber, respectively -31,51-38,87% and 65,66-62,47 %. *ceratoides latens* (*teresken*) seeds contain 27,85% protein, 45,22% fiber, 5,58% fat.

Table 3 shows the nutrient content in individual organs of the teresken.

Table 3. The content of nutrients in individual plant organs

Plant organs	Date and years of definition	Protein	Fiber	Ash	Fat	NES (nitrogen-free extractable substances)
Leaves	30.VII.2020	20.06	31.51	9.09	2.80	36.47
	15.VII.2021	-	38.87	9.16	3.55	-
Stems	30.VII.2020	-	65.66	10.06	1.12	-
	15.VII.2021	13.22	62.47	10.07	1.67	12.55
Seeds	3.X.2021	27.85	45.22	8.0	5.58	13.34

Discussion

One of the ways to preserve and increase the productivity of degraded pastures is to radically improve them by creating artificial phytocenoses, based on the scientific selection of species, taking into account the chemical, biological characteristics of plants in specific natural and climatic conditions of the improvement zone.

The vigor of the development of plant species roots and their specific distribution throughout soil somewhat affects physical, mechanical, and other soil properties (Shamsutdinova et al., 2019; Shagaipov, 2018; Arkincheev, 2016; Shamsutdinov et al., 2018; Callaway et al., 2000; Jakobs et al., 2004). Thus, the analyses of 0-5 and 10-15cm soil layers have demonstrated that the humus content decreases under *Eurotia* bushes compared to virgin land. Though the number of mobile potassium increases.

The latter is very good in the 0-5 cm layer (Table 4).

Table 4. Grain size composition of light sierozem on virgin land, on plowed land, and under *Eurotia ceratoides latens* bushes («Bukhtulen» experimental plot), 2021

Sampling location	Sampling depth (cm)	The content of the fraction in %						The amount
		1-0,12	0,25-0,05	0,05-0,01	0,01-0,001	0,0005-0,001	0,001	
Virgin land	0-5	10.6	75.0	8.6	1.8	2.2	1.8	5.8
	10-15	12.2	71.6	4.6	1.4	5.0	5.2	11.6
Plowed land	0-5	12.9	61.6	11.2	3.2	6.5	4.6	14.3
	10-15	10.1	66.0	5.0	9.5	4.6	4.8	18.9

Under Eurotia of the 2 nd year of life	0-5	15.3	67.5	8.8	1.8	4.4	2.2	8.4
	10-15	12.5	69.6	10.9	0.4	5.2	1.4	7.0
Under Eurotia of the 3 th year of life	0-5	11.8	67.7	9.9	2.8	4.8	3.0	10.6
	10-15	12.6	65.8	12.4	2.0	4.8	2.4	9.2

Table 5 summarizes the values of water-soluble substances in the plant. An increase in dust fraction (0,01+0,001 sum) is most noticeable. Thus, on plowed land in the 10-15 cm layer, the 0,01-0,001 fraction sum was 18,9, and under bushes of Eurotia ceratoides latens, it was 7,0–9,2%. Table 1 presents light sierozem's chemical and physico-chemical properties on virgin land, plowed land, and Eurotia ceratoides latens.

In 2021, the protein content in all phases was high, particularly in the phase of seed ripening since Eurotia plants intensely bore fruit. The maximum fiber content was noted in early winter (25. XII)—60,01%. Ash amount has almost no changes, neither by vegetation phases nor with the age of plants, and varies within 9,11–10,05%, respectively, with the 3,67–4,90 calcium content. In early winter, the protein amount decreased to 21,37%, while the fiber increased to 60.01%. Therefore, it affects the nutrient density of forage mass in winter. Determining the content of nutrients in various organs of plants: leaves and seeds are the most nutrient-dense.

Table 5. Content of water-soluble substances in the plant

Sampling depth, cm	Alkalinity		CO ₂	Ca	Mg	Total	NO ₃
	Total HCO ₃ ⁻	Carbonate CO ₃					
0-18	0.037 0.60	None	0.005 0.11	0.007 0.35	0.001 0.10	0.068	0.002 0.03
18-43	0.037 <u>0.60</u>	None	0.007 <u>0.15</u>	0.006 <u>0.30</u>	0.001 <u>0.10</u>	0.069	0.002 <u>0.03</u>
43-80	0.029 <u>0.48</u>	None	0.006 <u>0.12</u>	0.006 <u>0.40</u>	0.002 <u>0.15</u>	0.058	0.004 <u>0.06</u>
80-120	0.037 <u>0.60</u>	None	0.013 <u>0.28</u>	0.011 <u>0.55</u>	0.004 <u>0.30</u>	0.098	None
120-138	0.024 <u>0.40</u>	None	0.202 <u>4.20</u>	0.015 <u>1.20</u>	0.016 <u>1.30</u>	0.469	None
138-220	0.037 <u>0.60</u>	None	0.145 <u>7.25</u>	0.145 <u>7.25</u>	0.015 <u>1.25</u>	1.211	None

Conclusion

1. The range has been refined, and the ecological, phytocenotic, and biomorphological features of the introduced into cultivation indigenous semi-shrub species, *ceratoides latens* (grey sagebrush), have been studied.

2. Low-productive desert pastures of arid communities, sometimes enriched with semi-shrubs (*Artemisia seratina* and *Astragalus villosissimus*), can be reconstructed by creating highly productive agro-phytocenoses using *ceratoides latens*.

3. *ceratoides latens* (grey sagebrush) is a xerophilous polymorphic semi-shrub, including elements of biomorphology similar to taxa described from arid regions of Central Asia and Kazakhstan. It is closely related to *ceratoides evermanniana*, but differs in its less compact bush structure, branching mainly at the base, smaller size, and leaf shape. It has a wide range in Kazakhstan, forming mixed formations with numerous associations.

4. *ceratoides latens* (grey sagebrush) is among the valuable and promising forage plants for improving low-productive pastures in Southern Kazakhstan, distinguished by its unique biomorphological and eco-biological characteristics and economic value.

5. Laboratory germination of *ceratoides latens* seeds varies annually from 47 to 89%, while field germination ranges from 9.2 to 23.9%.

6. In the cultivation conditions of Kazakhstan's arid zone, *ceratoides latens* exhibits an accelerated pace of all ontogenetic stages. Its taproot intensively deepens into the soil in the first year of life, promoting better plant survival.

7. The vegetation period of *ceratoides latens* in the cultivation conditions of the arid zone of Southern Kazakhstan lasts from 196 to 216 days.

8. Hay yield in the 1st year of life is 5.0 tons/ha, and seed yield is 0.3 tons/ha. From the 2nd year onward, yields increase to 13.6-31.9 tons/ha and 1.2-2.5 tons/ha, respectively.

9. Establishing long-term, rich-pasture meadows for summer-autumn-winter use using the cultivated variety of *ceratoides latens* in the arid zone of Southern Kazakhstan is an economically advantageous measure, resulting in a 4-6 fold increase in productivity of ephemeral and wormwood forage lands.

Contributions of the Authors

Zhanaliyeva R.N. and **Imangaliyeva B.S.** developed the main concept of the study. **Zhanaliyeva R.N.** and **Torsykbaeva B.B.** designed the methodological approach for the research. **Zhanaliyeva R.N.** and **Torsykbaeva B.B.** verified and confirmed the accuracy of the data and results. **Zhanaliyeva R.N.** and **Yeskaraev N.M.** conducted the primary stages of the research. **Imangaliyeva B.S.** and **Ubaydullayeva N.A.** drafted and prepared the initial manuscript. **Ubaidulayeva N.A.** and **Sultanov N.A.** were responsible for translating the article into English and editing the review.

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Ceratoides latens сұр терескендердің химиялық қасиеттерін зерттеу

Андатпа. Бүгінгі таңда табиғи флораның көпжылдық өсімдіктері құрғақшылыққа және ыстыққа төзімді жем өсімдіктерін өндіруге арналған шикізат ресурсы болып табылады, олардың арасында *Eurotia ceratoides* ерекше орын алады.

Бұл жұмыста *Eurotia ceratoides latens* (J.F. Gmel) тұқымының химиялық қасиеттері зерттеліп, топырақтағы қарашірік мөлшері, анықталды, ашық сұр топырақтың химиялық және физика-химиялық қасиеттері (қарашірік, су, карбонат иондары, азот мөлшері) анықталды. Қарашірік құрамы органикалық көміртектің хром қышқылы мен көмірқышқыл газына дейін тотығуы негізінде анықталды.

Eurotia ceratoides Latens химиялық құрамы өсімдіктегі қоректік заттардың (ақуыз, талшық, май, азотсыз экстракцияланатын заттар, күл) және суда еритін заттардың (С, CO₂, Са, Mg) мөлшеріне талдау негізінде жасалды. Өсімдіктердегі күл мөлшері вегетациялық фазаларына сәйкес өзгермейтіні анықталды, ол өсімдіктердің жасына қарай 9,11-10,05% аралығында, ал сәйкесінше кальций мөлшері 3,67-4,90 деңгейінде болды. «Шикі» талшықтың құрамы Сокслет аппаратының көмегімен анықталды, топырақтағы кальций катиондарының құрамы комплексометриялық әдіспен бағаланды. Шикі ақуызды, шикі майды эфирлік экстракциялау әдісі арқылы анықтау үшін Кьельдал әдісі қолданылды және колориметриялық әдіспен аммоний оксалаты мен фосфордың қаныққан ерітіндісімен тұндыру арқылы күлдегі азотсыз экстракциялық заттар анықталды. Сонымен қатар, *Eurotia ceratoides latens*-тің тағамдық құндылығы айқындалды.

Түйін сөздер: терескен, *Eurotia ceratoides latens*, бұта *Eurotia*, химиялық қасиеттері, топырақ, Кьельдаль әдісі, Сокслет аппараты, Мор тұзы, комплексметриялық әдіс, сілтілік, карбонат.

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Изучение химических свойств серых терескенов *ceratoides latens*

Аннотация. Многолетние растения естественной флоры на сегодняшний день являются сырьевым ресурсом производства засухоустойчивых и термостойких кормов, среди которых особое место занимает *Eurotia ceratoides*.

В данной работе изучены химические свойства *Eurotia ceratoides latens* (J.F. Gmel) и проведено определение содержания гумуса в почве, выявлены химические и физико-химические свойства светлого серозема (содержание гумуса, воды, карбонат-ионов, азота). Содержание гумуса определяли на основе окисления органического углерода хромовой кислотой до диоксида углерода.

Химический состав *Eurotia ceratoides Latens* проанализирован на содержание в растении питательных веществ (белка, клетчатки, жира, безазотистых экстрагируемых веществ, золы) и водорастворимых веществ (С, CO₂, Са, Mg). Установлено, что в растениях содержание золы почти не меняется по фазам вегетации, с возрастом растений и колеблется в пределах 9,11-10,05% соответственно и содержания кальция было на уровне 3,67-4,90. Содержание «сырой» клетчатки определяли с помощью аппарата Сокслета, содержание катионов кальция в почве оценивали комплексонометрическим методом, методом Кьельдаля проведен анализ по определению сырого протеина, сырого жира методом эфирной экстракции, безазотистых экстрактивных веществ в золе путем осаждения ее насыщенным раствором оксалата аммония и фосфора колориметрическим методом. Выявлена пищевая ценность *Eurotia ceratoides latens*.

Ключевые слова: терескен, *Eurotia ceratoides latens*, полукустарник *Eurotia*, химические свойства, почва, метод Кьельдаля, аппарат Сокслета, соль Мора, комплексонометрический метод, щелочность, карбонат.

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Ғылыми мақала

Тікелей осмоста қолдану үшін полиэтилентерефталатты тректік мембраналардың тотығуы

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Аңдатпа. Бұл зерттеуде алғаш рет «үлкен құдық – кеуекті түбі» бірегей геометриясы бар тректік мембраналардың тотығуын талдау жүзеге асырылды. Олардың физикалық-химиялық сипаттамалары, оның ішінде беріктігі, ауа мен су бойынша өнімділігі, сондай-ақ гидрофобтық-гидрофильдік қасиеттері зерттелді. Зерттеу ерітінді концентрациясы мен кеуектің геометриясына байланысты сүзу ағынының өзгеруін қоса алғанда, тікелей осмос процестерінде мембраналардың өнімділігіне кеуектің пішіні мен мөлшерінің әсерін талдауды қамтыды. Осындай құрылымды мембраналар өздерінің механикалық қасиеттері мен өткізгіштігінің арқасында тікелей осмоста жоғары тиімділікті көрсетеді. Тотығудың оңтайлы жағдайлары мембраналардың гидрофильділігін жақсарту есебінен өнімділікті 28%-ға арттыруға ықпал етті, бұл олардың сүзгілеу қабілетінің ұлғаюына әкелді. Бұдан басқа, электр өткізгіштігі бойынша бағаланған суды тазарту деңгейі шамамен 100%-ға жететіні анықталды. Мембраналардың өнімділігі шоғырлану айырмашылығының өсуімен ұлғаюын байқау қызығырақ болып табылады, яғни бұл парциалдық қысымның ұлғаюына байланысты. Дегенмен, тікелей осмостан кейін мембраналарда каналдардың тұз шөгінділерімен ластанғаны анықталады, бұл сканерлейтін электрондық микроскопияның көмегімен расталды. Бұл қорытындылар өнеркәсіп пен коммуналдық шаруашылықта мембраналық технологияларды неғұрлым тиімді және экономикалық тиімді пайдалануды қамтамасыз ете отырып, сұйықтықтарды тазалау және сүзу саласында әртүрлі қолданулар үшін арнайы бейімделген мембраналарды жобалаудың жаңа тәсілдерін дамытуға ықпал етуі мүмкін.

Түйін сөздер: тректік мембраналар, тотығу, тікелей осмос, полиэтилентерефталат, гидрофильділік.

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Кіріспе

Соңғы бірнеше онжылдықта сұраныстың ұдайы өсуінен тұщы судың жетіспеушілігі адам қоғамының тұрақты дамуына қауіп төндіруде. Бұдан басқа, әртүрлі өнеркәсіптік төгінділер табиғи су ресурстарын ластап, елеулі экологиялық проблемалар туғызады. Сондықтан таза сумен қамтамасыз етудің шешуші мәні бар және суға өсіп келе жатқан қажеттілікті қанағаттандыру үшін қол жеткізілуі тиіс. Дистилляция [1], ион алмасу [2] және электродиализ [3] сияқты әртүрлі технологиялар таза су өндіру үшін зерттелді. Алайда бұл әдістер күрделі процедураларды талап етеді және энергияның көп мөлшерін тұтынады, немесе судың қайталама ластануына әкелетін көптеген химиялық заттарды қамтиды. Әлемдік су ресурстарының >97% -ын теңіз сулары құрайтынын ескере отырып, теңіз суын тұщыландыру суды тазартудың маңызды перспективалы әдісіне айналды [4].

Тұзсыздандыру – бұл тұзды судың құрамындағы тұздарды жою және адамның тұтынуына, сондай-ақ өнеркәсіптік және ауыл шаруашылығы мақсаттарына жарамды тұщы сумен қамтамасыз ету процесі және су тапшылығы дағдарысын шешу үшін сенімді және тиімді тәсіл ретінде қарастырылады [5]. Соңғы онжылдықтар ішінде мембраналық технология суды ғана емес, мұнай мен газды бөлудің және тазартудың кеңінен қолданылатын әдісіне айналды. Мембраналық бөлуді пайдаланудың артықшылығы химиялық заттардың болмауы немесе аздаған қажеттілігі, қарапайым алу және энергияны салыстырмалы түрде төмен тұтыну болып табылады.

Мембраналық тұщыландыру кезінде кері осмос (КО), тікелей осмос (ТО), микрофльтрация (МФ) [6], нанофльтрация (НФ) [7] және ультра сүзгілеу (УС) [6] әдістері қолданылады. Сүзгілеу процестері төрт топқа бөлінеді: МФ (0,1-2,0 мкм), УС (2-100 нм), НФ (1-10 нм) және КО (< 1 нм).

Қазіргі кезде суды тұщыландырудың неғұрлым пайдаланылатын әдістерінің ішінде КО-тың мембраналық процесі пайдаланылады. Тұщыландыру қысыммен басқарылатын типтік процесс болып табылады, онда қозғалтқыш күш ретінде сыртқы гидравликалық қысым қолданылады, ал еріген заттар жартылай өткізгіш мембранамен (КО мембранасы деп аталады) алынып тасталады [8].

КО - сұйықтық/сұйықтық бөлген кездегі ең қатаң мембраналық процесс түрі. Негізінен, су мембранадан өтетін жалғыз зат болып табылады; ал барлық еріген және өлшенген материал дерлік сүзіледі.

Сонымен қатар, қолда бар мембраналардың төмен өнімділігіне байланысты суды ТО-пен тазарту бағыты аз зерттелген тақырып болып табылады. Сонымен бірге, тазартудың осы әдісі тұзсыздандыру процесінің энергия шығынын айтарлықтай төмендетуі мүмкін, өйткені онда қысым айырмашылығы да, температура айырмашылығы да талап етілмейді. ТО – еріткіш молекулаларының, мысалы судың жартылай өткізгіш мембраналар арқылы тасымалдануын сипаттайтын осмостың табиғи құбылысы. Тік осмостағы еріткішті тасымалдаудың қозғаушы күші осмотикалық қысымның айырмасы болып табылады. Концентрацияланған ерітінді ерітіндінің/судың молекулаларын сұйылтылған ерітіндіден, мысалы тұздалған ерітіндіден жартылай өткізетін мембранадан тартады, бұл ретте өзі сұйылтылады. Алынған сұйылтылған ерітінді белгілі

бір температураға дейін қыздырылады, бұл ретте еріткіштің/судың бөлшектері буланады, ал онда зат тұндырылады не ыдырайды және бастапқы тұзды суға қарағанда концентрациясы аз ерітінді алынады. Сұйытылған ерітіндіні қайта циркуляциялау үшін қайта шоғырландырады.

Алайда өнеркәсіптік ауқымда тікелей осмосты қолдануға кедергі келтіретін бірқатар техникалық кедергілер бар. Тікелей осмостың алдыңғы зерттеулерінің нәтижелері бойынша тікелей осмостың эксперименттік ағыны әдетте ерітінділердің классикалық теориясы – диффузия бойынша есептелген оның теориялық мәндеріне қарағанда едәуір төмен екені белгілі [11-13]. Күтілгеннен төмен ағын массаны тасымалдау процесінде ішкі және сыртқы концентрациялық поляризацияның (ІКП және СКП) болуымен түсіндіріледі, бұл осмостың қолжетімді қозғаушы күшін едәуір төмендетеді [11]. Қиылысу ағысының неғұрлым төмен жылдамдығы шекаралық қабаттың қалыңдығын және СКП дәрежесін арттырады. Сыртқы концентрациялық поляризацияны гидродинамикалық бақылауға болады, бірақ ішкі поляризация мембрананың кеуекті төсемінде болуы, бұл оны басқаруда белгілі бір қиындықтар тудырады. Концентрацияның концентрациялық поляризациясы құбылысы еріген заттың физикалық қасиеттерімен, сұйықтықтардың динамикасымен және ең маңыздысы мембрананың құрылымымен байланысты. Осылайша, негізгі міндеттердің бірі концентрациялық поляризацияны барынша азайтуға қабілетті оңтайландырылған – ағынның айтарлықтай төмендеуінің негізгі себебі болатын мембрананы жасау болып табылады [10-12]. Мұндай мембрананың коммерциялық кері осмос мембраналарымен салыстырғанда жоғары өнімділігі болуы тиіс [1,4]. Осылайша, тікелей осмос мембраналарының қажетті сипаттамалары ішкі концентрациялық поляризацияның төмен мәндерін қамтамасыз ететін жоғары кеуектілікпен салыстырмалы түрде жұқа негізде ұсталатын еріген заттың су өткізгіштігі мен төмен өткізгіштігі бар тығыз ультра жұқа белсенді қабат болады [10,12]. Бұдан басқа, мембрана мембрананың ластануын азайту үшін гидрофильді болуы тиіс [14] және ұзақ пайдалануға шыдау үшін жоғары механикалық беріктікке ие болуы тиіс.

Мембраналық технология саласындағы көптеген жұмыстар әдістердің өнімділігін арттыруға, энергия шығындарын азайтуға және экологиялық проблемаларды шешуге бағытталған. Соңғы уақытта тікелей осмос әдісі барған сайын өзектілікке ие болуда, ол перспективада сарқынды суларды тиімді тазарту, теңіз суын тұщыландыру және басқалар үшін табысты қолданылуы мүмкін, әрі мұндай мембраналардың өнімділігі коммерциялық мембраналармен салыстырылуы тиіс. Осы мақсаттарға қол жеткізу үшін әлемнің түкпір-түкпірінен келген ғалымдар мембраналардың құрылымы мен морфологиясын, олардың бағдарын, сорғыш ерітіндісі мен қоректік ерітіндінің сипаттамаларын жетілдіруге күш салуда. Алайда, соңғы уақытта осы саладағы сөзсіз прогреске қарамастан, бұл тақырып әлемдік қоғамдастық үшін өзекті болып қалуда.

Осы жұмыс шеңберінде алғаш рет «үлкен құдық - кеуекті түбі» күрделі геометриялы ТМ тотығу бойынша зерттеулер жүргізілді. жарылуға беріктігі, ауа және су бойынша өнімділігі сияқты ТМ физикалық-химиялық қасиеттері зерттелді, тректердің геометриясы мен диаметріне байланысты, тікелей осмос процестерінде ТМ өнімділігіне зерттеу жүргізілді, сүзілетін сұйықтық ағынының өзгеруінің тректер геометриясына

тәуелділігі анықталды, ерітіндінің шоғырлануына байланысты сүзілетін сұйықтық ағынының өзгеру тәуелділігі анықталған, сондай-ақ ТМ-нің селективтілігі мен ластану дәрежесіне зерттеулер жүргізілген.

Тәжірибе әдістемесі

Зерттеу үлгілері. Зерттелетін полимерлік пленка қалыңдығы 23 мкм «Mitsubishi Polyester Film» (Германия) компаниясы шығарған Hostaphan® типті полиэтилентерефталаттан (ПЭТФ) таңдап алынды. Полимер пленканы сәулелеу ДЦ-60 ауыр иондар үдеткішінде екі кезеңде жүргізіледі. Мембраналар фотосенсибилизациядан кейін 2,2 М натрий гидроксиді ерітіндісінде химиялық өңдеуге ұшырайды, белгілі бір кезеңдер ішінде берілген өлшемдегі кеуектердің диаметрін алу үшін қолданылатын температура – 85°C.

Сондай-ақ тәжірибелерде мынадай реактивтер пайдаланылды: сутегі асқын тотығы, сірке қышқылы, тұз қышқылы, көк толуидин, деионизацияланған су, тазартылған су, натрий хлориді, олар х.т. және т.а.т.

ПЭТФ ТМ УК сәулелену әсерімен сутегі пероксидімен тотықтандыру. ПЭТФ ТМ (6,5 × 12 см²) үлгілерін рН = 3 (HCl) кезінде 0,3 моль концентрациясы H₂O₂ ерітіндіде тотықтандырды. Тотығу үш қатар эксперименттерде 15-180 мин. Сондай-ақ, ПЭТФ пленкадан УК-шамға дейінгі қашықтық 7, 10, 15 см шегінде өзгерді, Қышқылданғаннан кейін үлгілер екі рет деионизацияланған сумен жуылып, кептірілді. УК-сәулеленудің әсерімен тотығу OSRAM Ultra Vitalux E27 (UVA: 315-400 нм, 13,6 Вт; UVB: 280-315 нм, 3,0 В) 15-120 минутқа. ПЭТФ ТМ тотықтыруды жүргізу схемасы мен процесі алдыңғы жұмыстарда егжей-тегжейлі сипатталған [15-17].

Толуидинді көк бояу әдісімен функционалдық топтарды сандық бағалау

Түпкі карбоксил топтарын анықтау үшін рН = 10 (NaOH) концентрациясы 0,5 мМ көк толуидин ерітіндісінің 10 мл дайындалды. Өлшемі 1x1 см² ПЭТФ ТМ үлгілерін толуидин көк ерітіндісіне салып, бояғышты толық сіңіру үшін 3 сағат бойы ұсталынады. Алынған боялған үлгілер NaOH ерітіндісінде және деионизацияланған суда екі реттен жуылды.

Десорбция үшін боялған үлгілер 50% сірке қышқылының ерітіндісіне түсіріліп, 10-15 минут бойы ұсталды, Боялған сірке ерітіндісінің оптикалық тығыздығын $\lambda = 630$ нм кезінде анықтады. Калибрлеу кестесі бойынша карбоксил топтарының шоғырлануын табады.

Түрлендірілген мембраналардың құрылымы мен қасиеттерін физика-химиялық әдістермен зерттеу

Сулаудың шеткі бұрышын (СШБ) анықтау. Мембрананың гидрофильді-гидрофобты қасиеттерін анықтау үшін статикалық құлау әдісімен ұлғайған кезде сандық микроскоппен 1000X өлшенетін СШБ анықтау әдісі пайдаланылды.

Үлгіні арнайы заттық үстелге қойып, жиектері бекітілді. Содан кейін үлгіге шприц-дозатор көмегімен тамшы түсірілді. Тамшыны бір жағынан шам арқылы жарықтандырады, екінші жағынан микроскопты бейнекамераға түсіреді. Тамшы түсірілімдері арнайы ImageJ бағдарламасымен өңделді, онда тамшыны эллиптикалық сипаттау арқылы СШБ автоматты түрде есептеледі.

Бетті сканерлейтін электрондық микроскопиямен (СЭМ) зерттеу. JEOL JSM-7500F (SEM) сканерлейтін электрондық микроскоп ПЭТФ-ТМ модификациясына дейін және кейін ұяшықтардың диаметрлері мен морфологиясын сипаттау үшін пайдаланылды.

Бұл жұмыста үлгінің үстіңгі қабатының микроструктурасын зерттеу, сондай-ақ мембраналардың үстіңгі қабатындағы көздің диаметрін анықтау қайталама электрондар режимінде жүргізілген. Үдеткіш кернеу 1 кВ орнатылды, үлгінің алдында электрондарды тежеу және бастапқы шоқ энергиясын 100 В дейін төмендету жүзеге асырылды, Мембраналардың беті алтын қабатпен жабылды, бұл үлгінің бетінде статистикалық әлеуеттің жинақталуын болдырмау есебінен бейнелеу сапасын жақсартты. Тозандандыру қабатының қалыңдығын стандартты калибрлеу кестесі бойынша ток пен тоздандыру уақытын (15-20 нм аспайтын) таңдау жолымен анықтады.

Нәтижелер мен талқылаулар

Алынған тректік мембраналардың параметрлері 1 кестеде берілген.

1-кесте. Күйдірудің әртүрлі уақытында өлшенген СЭМ каналдарының диаметрлері

Күйдіру уақыты, с	SEM бойынша диаметрі «кеуекті түбі», (конустың негізі) нм	SEM бойынша диаметрі «құдықтар», мкм	Конустың жоғарғы диаметрі «кеуекті түбі» (өткізгіштігі бойынша), нм
10	20	2,01	0,8
20	17	2,01	1,4
30	35	2,02	2,1
40	50	2,20	2,8
60	73	2,20	3,1
80	100	2,32	5,6
100	130	2,33	8,5
160	278	2,46	-
200	288	2,50	-
240	293	2,85	-
560	429	-	-

Одан әрі мембраналардың гидрофильді қасиеттерін арттыру және тікелей осмос өнімділігін арттыру мақсатында OSRAM Ultra Vitalux E27 (UVA: 315-400 Нм, 13,6 Вт шамдарының көмегімен ультракүлгін сәулелену арқылы экологиялық таза және техноогиялық тұрғыдан оңай жүзеге асырылатын сутегі тотығында мембраналарды тотықтандыру жүргізілді; UVB: 280-315 нм, 3.0 В). Тректік мембраналардың үлгілері (5 × 7,5 см²) концентрациясы 300 мМ Н₂О₂ ерітіндісінде рН = 3 (HCl) кезінде тотықтандырылды.

Қышқылдандыру үлгіден УК-шамға дейінгі арақашықтық 15-180 минут бойы үш қатар экспериментте 5-тен 15 см-ге дейін жүргізілді. Қышқылданғаннан кейін үлгілерді екі рет деионизацияланған сумен жуып, 5 сағат бойы бөлме температурасында ауада кептіреді.

Процестің тиімділігі сулаудың шеткі бұрышының (СШБ) өзгеруі бойынша, сондай-ақ мынадай әдістеме бойынша өлшенген карбоксильді топтардың шоғырлануының өзгеруі бойынша бақыланды: мөлшері 1 см² ПЭТФ ТМ үлгісі $5 \cdot 10^{-4}$ М шоғырланумен ТК 10 мл сілтілі ерітіндіге (NaOH, pH = 10) орналастырылды және 3 сағат бойы шейкерде үздіксіз сілкіп, осылайша бояғыштың мембрананың бетіне барынша толық сіңуін қамтамасыз етеді. Сілкілеу аяқталғаннан кейін үлгіні NaOH (pH = 10) ерітіндісінде және екі рет деионизацияланған суда жуып, содан кейін ауадағы сүзгі қағазында кептіреді. Боялған үлгілерді десорбциялауды 5 мл 50% сірке қышқылының ерітіндісінде шейкерде қарқынды сілкілеу кезінде 10 мин бойы жүргізді. Боялған ерітіндінің оптикалық тығыздығын толқынның ұзындығы 633 нм болғанда анықтаған, түпкі карбоксильді топтардың шоғырлануын калибрлеу кестесі бойынша анықтаған.

Беріктік қасиеттерін анықтау зертханалық қондырғыдағы мембранға төзімді болатын ең жоғары қысымды анықтау әдісімен жүргізілді. Қондырғы баяу өзгертін қысыммен жүктеу кезінде ТМ зертханалық үлгілерінің үзілуіне беріктікті өлшеуге арналған.

СШБ, карбоксил топтарының шоғырлануы мен үзілуге беріктігін өзгерту нәтижелері 2 кестеде келтірілген. Бұл ретте бастапқы мембранамен 40 с химиялық өңдеу уақыты бар мембрана таңдалды.

Ұсынылған деректерден көрініп тұрғандай, УК-шамға дейінгі арақашықтық – 10 см, тотығу уақыты мембрананың әрбір жағынан 60 минуттан. Бұл жағдайларда үлдірдің барынша гидрофилизациясы болады, бұл беріктік сипаттамаларын сақтаумен бірге СШБ өзгеруінен және карбоксил топтарының шоғырлануынан көрінеді. Әртүрлі жағдайларында су тамшыларының фотосуреттері 3 кестеде берілген.

2-кесте. Үлгіден УК-көзіне дейінгі қашықтыққа және тотығу уақытына байланысты СШБ және карбоксил топтарының концентрациясының өзгеруі

Үлг. №	УК-көзіне дейінгі қашықтық, см	Сәулелену уақыты, мин	СШБ, ⁰	[COOH], мкМ/г	Үзілуге беріктігі, МПа
1	-	0	65	3,4	>0,7
2	7	15	62	5,4	>0,7
3	7	30	61	7,2	0,23
4	7	60	60	10,5	0,11
5	7	90	59	19,4	0,04
6	10	15	61	8,3	>0,7
7	10	30	61	8,6	0,47
8	10	60	58	10,7	0,39

9	10	90	57	22	0,11
10	15	15	60	4,4	>0,7
11	15	30	60	4,6	0,23
12	15	60	57	4,8	0,17
13	15	90	62	7,5	0,10
14	15	120	45	14,8	0,04
15	15	180	44	39,6	0,04

Тректердің диаметрлері мен арналар геометриясына байланысты ТМ өнімділігін тікелей осмос режимінде бағалау үшін «үлкен құдық – кеуекті түбі» – 1,2Е + 06/1,0Е + 09 геометриясы бар, қалыңдығы 20 мкм, тректердің әртүрлі диаметрлері бар, сондай-ақ тотығуға дейін және кейін ПЭТФ негізінде мынадай мембраналар таңдалды: бұрын табылған оңтайлы жағдайлар. Алынған мембраналардың өнімділігін зерттеу үшін тікелей осмос процестерінде 10 мМ NaCl (сүзілетін ерітінді) және 1-4 М NaCl (сорғыш ерітіндісі) қолданылды. Ағындардың жылдамдығы перестальтикалық сорғыштардың көмегімен бақыланды.

Теориялық байқау қысымы эксперимент басында тұз концентрациясын пайдалана отырып, Вант-Холф теңдеуі бойынша есептелген:

$$\pi = i \frac{\Delta CRT}{M_i} \quad (1)$$


мұндағы i – Вант-Холф коэффициенті және мінсіз ерітінділер үшін 2-ге тең.












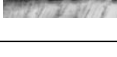

Эксперимент кезінде қозғалыстағы осмостың күші сорғыш ерітіндісінің сұйылуынан азаяды.

1 суретте химиялық өңдеу уақытына байланысты тікелей осмос процесінде су ағысының өзгеру диаграммалары берілген. Химиялық уақытының ұлғаюымен өнімділіктің артуы байқалады, бұл табиғи түрде мембраналардың көздері көлемінің ұлғаюымен байланысты.

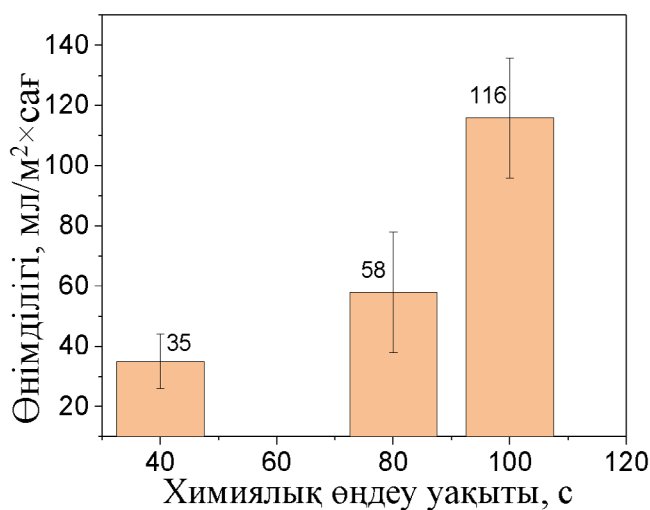
2 суретте мембраналардың өнімділігінің сорғыш концентрациясына тәуелділігі берілген. Сондай-ақ ерітінділер концентрациясының айырмашылығының ұлғаюымен өнімділіктің артуы байқалады, бұл парциалдық қысымның ұлғаюымен түсіндіріледі.

3-кесте. Сәулелену уақытына және УК-көзіне дейінгі қашықтыққа байланысты тамшылар нысандарының өзгеруі

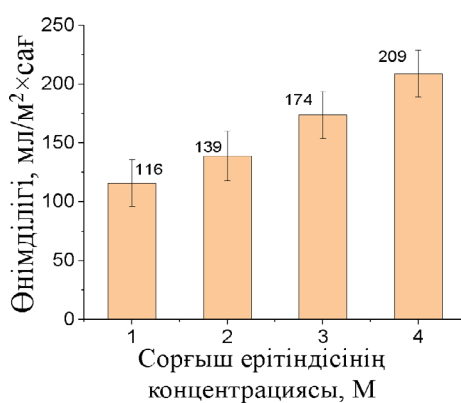
Үлг. №	УК-көзіне дейінгі қашықтық, см	Сәулелену уақыты, мин	Тамшы суреті
1	-	0	

2	7	15	
3	7	30	
4	7	60	
5	7	90	
6	10	15	
7	10	30	
8	10	60	
9	10	90	
10	15	15	
11	15	30	
12	15	60	
13	15	90	
14	15	120	
15	15	180	

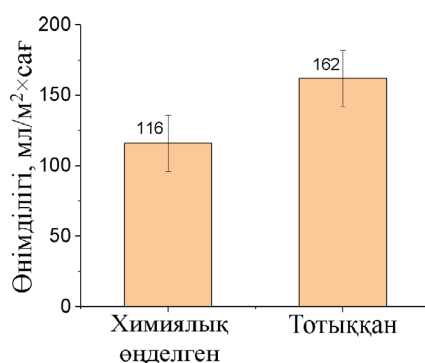
Сондай-ақ оңтайлы жағдайларда қышқылданудың сұйықтық ағынының жылдамдығына әсері зерттелді. Тікелей осмос өнімділігінің 28% -ға артқаны байқалады. Тотығу мембраналардың гидрофильді қасиеттерінің ұлғаюына әкеледі, бұл өз кезегінде өнімділіктің ұлғаюына әкеледі (3 сурет).



1-сурет. Химиялық өңдеу уақытына байланысты тікелей осмос өнімділігінің өзгеруі



2-сурет. Сорғыш ерітіндісінің концентрациясына байланысты тікелей осмос өнімділігінің өзгеруі



3-сурет. Тотыққан және химиялық өңделген ПЭТФ ТМ үшін тікелей осмос өнімділігінің өзгеруі

Барлық мембраналар үшін электр өткізгіштігі бойынша бағаланған тазалау деңгейі шамамен 100% -ды құрайтынын атап өткен жөн. ТО кейін мембраналар СЭМ әдісімен зерттелді. Мембраналар арналарының тұзды шөгінділермен ластануы байқалады.

Нәтижелерге сүйене отырып, күйдіру уақытының ұлғаюымен өнімділіктің артуы байқалады, мембраналардың гидрофильділігі тотығу салдарынан ұлғайды. Сондай-ақ сорғыш ерітінділері концентрациясының айырмашылығының ұлғаюымен өнімділіктің ұлғаюы байқалады. Бірақ мембраналар арналарының ұзақ пайдаланудан кейін ластануы әлі де байқалады.

Қорытынды

Бұл жұмыста мембраналарды гидрофилизациялау мақсатында «үлкен құдық - кеуекті түбі» геометриясы бар тректік мембраналардың ПЭТФ тотықтыру әдістері зерттелді. Алынған мембраналар үзілуге беріктік әдістерімен, сулану шеткі бұрышын және карбоксил топтарының концентрациясын айқындаумен сипатталған. Кеуектердің әртүрлі өлшемдері мен гидрофилденген беті бар алынған мембраналар тікелей осмос әдісімен суды тұзсыздандыруда сыналған.

«Үлкен құдық – кеуекті түбі» геометриясы бар мембраналар өзінің беріктік қасиеттерінің, өнімділігі мен өткізгіштігінің арқасында тікелей осмос процестерінде қолдану үшін перспективалы материал болып табылады. Оңтайлы жағдайларда сұйықтық ағынының жылдамдығына тотығудың әсерін зерттеу тікелей осмос өнімділігінің 28% -ға ұлғайғанын көрсетті. Тотығу мембраналардың гидрофильді қасиеттерінің артуына әкеледі, бұл өз кезегінде өнімділіктің артуына әкеледі. Барлық мембраналар үшін электр өткізгіштігі бойынша бағаланған тазалау деңгейі шамамен 100% -ды құрағанын атап өткен жөн. Сондай-ақ ерітінділер концентрациясының айырмашылығының ұлғаюымен өнімділіктің ұлғаюы байқалады, бұл парциалдық қысымның ұлғаюымен түсіндіріледі. Алайда, тікелей осмостан кейін, СЭМ әдісімен зерттелген мембраналарда мембраналар арналарының тұзды шөгінділермен ластануы байқалады.

Мүдделер қақтығысы жоқ

Авторлардың қосқан үлесі

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Қаржыландыру: жоқ

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Окисление полиэтилентерефталатных трековых мембран для применения в прямом осмосе

Аннотация. В данном исследовании впервые осуществлен анализ окисления трековых мембран с уникальной геометрией пор "большой колодец – пористое доньшко". Были изучены их физико-химические характеристики, включая прочность, производительность по воздуху и воде, а также гидрофобно-гидрофильные свойства. Исследование охватило анализ влияния формы и размера пор на производительность мембран в процессах прямого осмоса, включая изменение потока фильтрации в зависимости от концентрации раствора и геометрии пор. Выявлено, что мембраны с такой структурой пор демонстрируют высокую эффективность в прямом осмосе, благодаря своим механическим свойствам и проницаемости. Оптимальные условия окисления способствовали повышению производительности на 28% за счет улучшения гидрофильности мембран, что привело к увеличению их фильтрационной способности. Кроме того, было установлено, что уровень очистки воды, оцененный по электропроводности, достигает приблизительно 100%. Интересным является наблюдение, что производительность мембран увеличивается с ростом разности концентраций, что обусловлено увеличением парциального давления. Тем не менее, после прямого осмоса в мембранах обнаруживается загрязнение каналов соляными отложениями, что было подтверждено с помощью сканирующей электронной микроскопии. Эти выводы могут способствовать развитию новых подходов к проектированию мембран, специально адаптированных для различных применений в области очистки и фильтрации жидкостей, обеспечивая тем самым более эффективное и экономически выгодное использование мембранных технологий в промышленности и коммунальном хозяйстве.

Ключевые слова: трековые мембраны, окисление, прямой осмос, полиэтилентерефталат, гидрофильность.

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Oxidation of poly(ethylene terephthalate) track-etched membranes for using in direct osmosis

Abstract. This study is the first to analyze the oxidation of track-etched membranes with a unique "large well – porous bottom" pore geometry. Their physical and chemical characteristics including strength, air, water performance, and hydrophobicity-hydrophilicity properties were studied. The study covered the analysis of the effect of pore shape and size on membrane performance in direct osmosis processes, encompassing the variation of filtration flux as a function of solution concentration and pore geometry. Membranes with this pore structure exhibit high performance in direct osmosis due to their mechanical properties and permeability. Optimal oxidation conditions contributed to a 28% increase in performance by improving the hydrophilicity of the membranes, leading to an increase in their filtration capacity. In addition, it was found that the level of water purification evaluated by electrical conductivity reached approximately 100%. The membrane performance increases with increasing concentration difference due to the rise in partial pressure. Nevertheless, after direct osmosis, the membranes show fouling of the channels with salt deposits, according to scanning electron microscopy data. These findings may contribute to the development of new approaches to the design of membranes specifically adapted to different applications in the field of liquid purification and filtration. This could result in more efficient and cost-effective use of membrane technologies in industry and utilities.

Keywords: track-etched membranes, oxidation, direct osmosis, poly(ethylene terephthalate), hydrophilicity

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Шолу мақала

Жол жабынының құрылымдық қабаттарында жүн және мұнай қалдықтарын геотордың толтырғышы ретінде пайдалану (шолу)

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Аңдатпа. Бұл шолу жұмысы ауыл шаруашылығында қолданыс таппаған қой жүні мен мұнай өндіру орындарындағы топыраққа төгілген мұнай және мұнай қалдықтарын жол төсемінің құрылымы жақсарту үшін қолдануға арналған. Толтырғыш ретінде қолданғаннан кейінгі малдың, мысалы, қойлардың жүнінен жасалған плиткалардың бетіне мұнай ластаушы заттарды сіңіргеннен кейін пайдалануға қол жеткізіледі. Қой жүнінің барлық түрі емес, іске аспай қалған түрлері алынатындықтан, сол жайлы мақалаларға назар аударылған және оларды өңдеу жолдары қарастырылады. Ұсынылып отырған жұмыс экологиялық мәселені шешуге де септігін тигізеді.

Мұнай ластаушы заттармен сіңдірілген плиткалар жол төсеміне дайындалған геоторларға салынады. Геотордың геометриялық өлшемдері аймақтың климаттық жағдайларына және жол төсемінің жағдайына байланысты таңдалады. Жол төсемдерін салудың ұсынылған әдісі жолдардың сапасын жақсартуға мүмкіндік береді.

Жол жамылғысын салудың бұл әдісі құрылыс шығындарын азайтады, ал жолдың қызмет ету мерзімін ұлғайту мұнай қалдықтарымен сіңдірілген плиткаларды пайдалану арқылы қол жеткізіледі, олар ылғалды сіңірмейді және оның жабынның корпусына енуіне жол бермейді, нәтижесінде қыста жол жарылмайды.

Түйін сөздер: жол жабыны, киіз, кноп, геотор, жабынның құрылымы, мұнай қалдықтары, мұнайшламдары, толтырғыш, шайыр.

Кіріспе

Заманауи ресурс үнемдейтін табиғи және техногендік шикізат негізіндегі жол құрылыс материалдары автомобиль жолдарының құнын төмендетуге және қоршаған ортаны жақсартуға айтарлықтай мүмкіндік береді. Жол құрылысындағы экономикалық және экологиялық алғышарттарды ескерсек, өңдеуге арналған минералды материалдар мен топырақтың, қымбат байланыстырғыш заттардың қолданысын азайтып, материалдың негізгі бөлігі техногендік шикізат пен өнеркәсіп қалдықтарын, соның ішінде мұнай шламын және ауыл шаруашылығы қалдықтарын қолдану болып табылады.

Жыл сайын статистика бойынша Қазақстанда 30 мың тоннаға жуық жүн өндіріледі, оның 2 мың тоннасы өңделеді, қалған шикізат бақылаусыз экспортталады. Жүннің 43 пайызы өңделмей, жоғалады. Қазіргі уақытта киіз өндіру үшін шикізат ретінде қолданылатын жүннің түрлері мен өндірушілері көп. Жүннің сапасы жіңішкелік, ұзындық, иілгіштік, беріктік, созылғыштық, серпімділік, икемділік, түсі, жылтырлығы, ылғалдылығы, шайыры сияқты көрсеткіштермен, сондай-ақ әр түрлі үлгідегі талшықтардың пайыздық мөлшерімен: мамығы, өтпелі түгі және қылқанымен анықталады [1, 2].

Арнайы әдебиеттерді [3] және басқа да ақпарат көздерін [4, 5] талдау әртүрлі елдерде жүнге қойылатын талаптардың айырмашылығына қарамастан, нақты жобаны немесе өндірістік тапсырманы шешуге арналған шикізат ретіндегі талшықты таңдауға бірінші кезекте әсер ететін сапалық сипаттамаларын анықтауға мүмкіндік берді.

Негізгі бөлім

Мұнайдың төгілуін локализациялаудың көптеген әдістері бар. Бірі қорғаудың ең маңызды әдістері қоршаған ортаны, әсіресе гидросфераны, сорбциялық материалдарды пайдалана отырып, мұнай өнімдерінің төгілуін локализациялау болып табылады. Қазіргі заманғы басым міндеттердің бірі қоршаған ортаны қорғау үшін мұнай мен мұнай өнімдерін жою үшін жоғары тиімді сорбциялық материалдарды іздеу болып табылады. Қазіргі уақытта әлемде төгілген мұнайдан тазалау үшін екі жүзге жуық әртүрлі сорбенттер қолданылады, олар: бейорганикалық, табиғи органикалық және органоминералды, сонымен қатар синтетикалық болып бөлінеді. Сорбенттердің сапасы негізінен олардың мұнай және мұнай өнімдеріне қатысты көлемімен, гидрофобтылық дәрежесімен, сорбциядан кейінгі қалқымалығымен және десорбция мүмкіндігімен анықталады.

Көптеген мұнай өндіретін жерлерде топыраққа немесе құмға төгілген мұнайды бөліп алу үшін зерттеу жұмыстары жүргізілуде. Құмды мұнайдан тазарту агенті ретінде натрий силикатын мұнай құмын бөлуге қолданған. Бұл мақала негізінен мұнай құмын бөлу қолданбасында ультрадыбыстық толқынды көмек функциясы ретінде қарастырылғаны талқыланады Эксперименттер арқылы ультрадыбыстық толқынды көмек функциясының мұнай құмын бөлу жағдайы талқыланған. Алдын ала нәтижелер дыбыстан жоғары функцияның астында тазартқыш агент пен мұнай құмының қатынасы 0,8:1, 60 °C ультрадыбыстық діріл 13 мин және оның мұнай алу жылдамдығы 94% жетуі

мүмкін екенін көрсетеді. Үгітпен салыстырғанда, зерттеу нәтижелері дыбыстан жоғары толқын әрекеті мұнай құмының алыну жылдамдығын едәуір арттырып қана қоймай, сонымен қатар өзіндік құнын төмендететінін дәлелдейді [6].

Мұнайлы құмдардан органикалық бөлікті бөлу әдістері тәжірибе жүзінде зерттелген. Авторлардың зерттеу нәтижелері көрсеткендей, экстракция әдісімен зерттелген Қазақстандағы Беке және Мұнайлы-Мола мұнайлы құмдарының органикалық бөлігі 12,0 масс.% және 16 масс.% құрайды. Термиялық өңдеу нәтижелері Беке және Мұнайлы-Мола мұнайлы құмдарының органикалық бөлігі массасының 9,6% және массасы 13,5% екенін көрсетті. Сұйық фракцияның физикалық және химиялық сипаттамалары стандартты әдістермен белгіленген [7].

Мұнай төгілулерін локализациялаудың алуан түрлі әдістері бар және қоршаған ортаны қорғаудың маңызды әдістерінің бірі мұнай төгілулерін сорбциялық материалдармен оқшаулау болып табылады. Қазіргі уақытта қоршаған ортаны қорғаудың қазіргі заманғы басым міндеттерінің бірі мұнай мен мұнай өнімдерін алу үшін жоғары тиімді сорбциялық материалдарды іздеу. Ең жақсы табиғи сорбенттердің бірі – жүн: оның бір килограммы 8-10 кг-ға дейін мұнай сіңіре алады, ал жүннің табиғи серпімділігі мұнайдың жеңіл фракцияларының көпшілігін сығып алуға мүмкіндік береді. Дәл осы сорбциялық материал мұнай өндіру платформасындағы апаттан кейін Мексика шығанағында төгілген мұнайды сіңіру үшін ұсынылған. Дегенмен, бірнеше сығудан кейін жүн битумдалған киізге айналады және қолдануға жарамсыз болып қалады. Жүннің жоғары құны және сақтаудың қатаң талаптары (жүн кеміргіштер, жәндіктер үшін өте тартымды, биохимиялық өзгерістерге ұшырайды) перспективті сорбент ретінде қарастыруға мүмкіндік бермейді. Сондықтан жүн шикізатын өңдеуден қалған мұнай қалдықтарының және мұнай өнімдерінің сорбенттері ретінде пайдалану перспективалы болып көрінеді [8]. Авторлардың мұнай мен мұнай өнімдеріне сорбциялық материал ретінде пайдалануы жүннің өңдеуден кейінгі қалдықтарын, яғни киізден жасалған бұйымдарды тарау кезінде түзілетін қысқа ұзындықты жүн талшықтарын зерттеуге мүмкіндік берді. Жүнді химиялық модификаторлармен өңдеу жүн талшықтарының химиялық құрамының өзгеруіне, сондай-ақ беттік құрылымының өзгерістеріне алып келеді. Зерттеу үшін қышқылды және қышқылсыз өңдеу технологиялары қолданылды. Қышқыл ерітіндісімен дегидратация орындалады, ол этерификация процесінің жүру шартына негізделген, яғни жүн кератиніне гидрофобты қасиеттер беретін эфир топтарының түзілуі.

Жаңа байланыстардың пайда болуы күкірт қышқылының ерітіндісімен өңделген таза кноп ИҚ спектрлерімен және оның модификациясымен расталады, онда С-О-С тобы тербелістерге сәйкес 1100 см^{-1} аймағында шыңның қарқындылығының жоғарылауы байқалады және сипаттарының $400\text{-}800\text{ см}^{-1}$ аймағындағы спектр өзгеруімен дәлелденеді. Әлбетте, бұл жағдайда жүн кератинінің химиялық модификациясы жаңа химиялық байланыстардың пайда болуымен байланысты органикалық және бейорганикалық қышқылдардың әсерінен орын алады. Дегенмен, құрамында 21 аминқышқылдары бар жүн талшығы құрылымының күрделілігін ескере отырып, қышқылдармен өңдеуден кейінгі кноп модификацияларының ИҚ спектрлерін нақтырақ түсіндіру мүмкін емес.

Шамасы, кератин құрылымындағы бұл өзгерістер жоғарыда аталған мұнай өнімдері қалдықтарына қатысты сорбциялық қабілетінің айырмашылығын түсіндіру болып табылады. Кнопты химиялық реагенттермен өңдеу жүн талшығының химиялық құрамының өзгеруіне ғана емес, сонымен қатар бетінің құрылымының өзгеруіне әкеледі. Күкірт қышқылының әсері кутикула қабыршақтарының ашылуына және жүн түктерінің сырқы қабатының талшықтануына ықпал етеді, бұл қабыршақтардың ұзындығы бойынша таралуынан көрінеді. Осылайша, модификацияланбаған кноп үшін қабыршақтардың ең көп мөлшерінің (10%) биіктігі 150 нм. Күкірт қышқылының ерітіндісімен өңдегенде қабыршақтардың ең көп мөлшері (10%) биіктігінің 200 нм-ге дейін ұлғаюына әкеледі. Осылайша, атқарылған жұмыстардың нәтижелері бойынша жүн шикізатын өңдеу қалдықтарының мұнай сыйымдылығы мен гидрофобты қасиеттерін арттыру үшін қышқыл ерітінділерінің өзара әрекеттесу параметрлері анықталды.

Динамикалық жағдайда анықталған зерттелетін сорбциялық материалдың мұнай сыйымдылығы кноп-К үшін 12,83 г/г, кноп-Я үшін 10,70 г/г болды.

Тәжірибе нәтижелері қышқыл ерітіндісімен өңделген кноппен салыстырғанда қышқылсыз кноптың ең жақсы мұнай сорбциялаушы материал екенін көрсетті. Бірақ эмульсияланған, еріген күйінде және су бетінде қалқымалы қабат түзетін мұнай өнімдеріне сорбциялық материалды қолданғанда мұнай өнімдерін сіңірумен бірге су да сіңеді, бұл сорбциялық материалдың мұнай сыйымдылығын төмендетеді. Мұнай сыйымдылығының көрсеткішін жоғарылату, әдебиет көздеріне сәйкес [9], сорбциялық материалдарды өзгерту арқылы мүмкін болады.

Жолдар мен көшелердің құрылымдық беріктігі, сондай-ақ беріктіктің біркелкілігі деформация модулімен сипатталатын жол төсемінің төменгі қабатының, астарлы қабатының және қабаттарының жобалық беріктігімен қамтамасыз етілетіні белгілі, оның мәні жабынның құрылымдық қабаттары үшін қолданылатын материалдардың қасиеттері және қабаттардың қалыңдығына тәуелді. Жол немесе көше жабындарын салу және оны пайдалану кезінде көліктерден тұрақты статикалық және динамикалық жүктемелер пайда болуы мүмкін, бұл жер асты қабатының аязымен араласуына және мұнайдың кездейсоқ төгілу өнімдеріне әкелуі мүмкін. Ұқсас процесс аязға төзімді жабынның қабаты мен ірі агрегат бөлшектерінен жасалған негіздің арасында болуы мүмкін. Нәтижесінде жолдың немесе көшенің әртүрлі құрылымдық қабаттарының аралас материалдары бүкіл құрылымның беріктігі мен ұзақ мерзімділігіне әсер етуі мүмкін [10].

Бүкіл әлемде соңғы 15 жылда жолдарды немесе көшелерді салу кезінде немесе пайдалану кезеңінде әртүрлі құрылымдық қабаттардағы толтырғыштардың араласуын болдырмау үшін геотекстильді пайдалану ұсынылады. Американдық зерттеушілердің ұсыныстарына сәйкес, құрылымдық қабаттарды бөлу үшін қолданылатын геотекстильдер қолданыстағы формулаларға сәйкес таңдалуы керек. Дегенмен, бұл формулалар асфальтбетон жабыны жоқ жол құрылымдары үшін ғана жарамды. Геотекстильді таңдаудың тағы бір әдісі - әртүрлі елдердің техникалық сипаттамалары мен ұсыныстары. Қазіргі уақытта жол немесе көше жабынының қабаттарын бөлуге арналған геотекстильді таңдауды реттейтін жалпы қабылданған еуропалық сипаттамалар жоқ.

Себебі, Еуропа елдерінің әртүрлі климаттық және геологиялық жағдайлары әртүрлі. Литва соңғы онжылдықта геотекстильді тек жолдарда және көшелерді салу мен қайта құруда ғана пайдаланып келеді. 1998 жылы Литва жол департаменті жол құрылысына геотекстильді және геогридтерді пайдаланудың уақытша ережелерін қабылдады. Ережелер неміс тіліне негізделген жолдарда геотекстильді қолдану тәжірибесі мен олардың спецификациялары, олардың Литва жағдайларына сәйкестігі бағаланды.

Ағынды сулар шламының күлін (SSA) жол төсемдерінде пайдалану бағаланады, оның байланыспаған, гидравликалық байланысқан және битуммен байланысқан формаларында қолданылуы қарастырылады [11]. Бос жабу немесе негіз ретінде материал өте жақсы разрядқа байланысты қолайлы емес, сондықтан бұл салада ең аз жұмыс бар. Гидравликалық байланыстырылған қабаттарда SSA жаңа бетонмен араласады, содан кейін негізгі материалды қалыптастыру үшін қатайтылады және ұсақталады, сонымен қатар қатты жабын беттері бар бетон плиталарында ішінара ұсақ толтырғыш ретінде қолданылады. Материал көбінесе битуммен байланыстырылған минералды толтырғыш және ұсақ толтырғыш ретінде, соның ішінде бірқатар толық ауқымды жобаларда қолданылады. Сонымен қатар, бағдарлама құрамында SSA бар жол төсемдерін шаймалауға қатысты экологиялық бағалауды қамтиды.

Топырақты мұнай және мұнай өнімдерімен ластанудан тазартудың белгілі әдісі бар, ол сорбент материалының бетіне ластаушы заттардың адсорбциясын қамтиды, онда сорбент материалы ретінде мал жүнінен жасалған плиткалар қолданылады. Әдіс жылу оқшаулағыш материал ретінде мұнай ластаушы заттармен сіңдірілген плиталарды қолдануды қамтиды [12].

Қорытынды

Авторлар жүннің сапасы, оны пайдалану және өңдеу туралы әдебиеттік деректерді зерделей отырып, дайын жол төсеміне мұнай ластанғыштарымен сіңдірілген қой жүнінен жасалған плиткалармен толтырылған геоторды төсеуді және оны төсеуді қамтитын жол жамылғысын салу әдісі ұсынып отыр және пайдалы модельге патент алынды [13].

Қазақстандағы ауыл шаруашылығының жүн қалдықтарын геогридтерге толтырғыш ретінде пайдалануды көлік жолдарында қолдану өзекті және тиімді деп санаймыз.

Авторлардың қосқан үлесі

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Использование отходов шерсти и нефтепродуктов в качестве наполнителя георешеток в конструктивных слоях дорожного покрытия (обзор)

Аннотация. Данная обзорная статья раскрывает тему использования сельскохозяйственной неиспользованной овечьей шерсти и нефтепродуктов, пролитых на почву с объектов нефтедобычи для улучшения структуры дорожного покрытия. Полученные в результате пропитки наполнителя из шерсти животных, например, овечьей шерсти, нефтезагрязнителями плитки могут использоваться в качестве дорожного покрытия. Поскольку используют не все виды овечьей шерсти, уделено внимание неиспользуемым видам шерсти и рассмотрены способы их обработки. Предлагаемая работа также помогает решить экологическую проблему.

Плитки, пропитанные нефтезагрязнителями, укладываются на георешетки, подготовленные к дорожному покрытию. Геометрические размеры георешетки выбираются в зависимости от климатических условий региона и состояния дорожного покрытия.

Предлагаемый способ укладки дорожных покрытий позволяет улучшить качество дорог и снижает затраты на строительство. Более того, достигается увеличение срока службы дороги за счет использования плитки, пропитанной остатками масла, которое не впитывает влагу и не позволяет ей проникать в тело дорожной одежды, в результате чего дорога зимой не трескается.

Ключевые слова: дорожное покрытие, войлок, кноп, геосетка, структура поверхности, нефтеотходы, нефтешламы, наполнитель, смола.

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The use of waste wool and petroleum products as a filler for geogrids in the structural layers of the road surface (review)

Abstract. This review article explores the use of agricultural unused sheep wool and petroleum by-products spilled on the soil to improve the structure of road surfaces. Tiles obtained by saturating a filler made from animal hair, such as sheep's wool, with oil pollutants can be used as a road surface. Since not

all types of sheep wool are used, attention is paid to unused types of wool and methods of processing them. Furthermore, the proposed work contributes to the resolution of an environmental problem.

Tiles saturated with oil pollutants are laid on geogrids prepared for the road surface. The geometric dimensions of the geogrid are selected depending on the climatic conditions of the region and the condition of the road surface.

The proposed method of laying road surfaces improves the quality of roads and reduces construction costs. Moreover, an increase in the service life of the road is achieved through the use of tiles impregnated with residual oil, which does not absorb moisture and does not allow it to penetrate into the road pavement. This results in the prevention of cracking in the road during the winter season.

Keywords: road surface, felt, button, geogrid, surface structure, oil waste, oil sludge, filler, resin.

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Method of classification and quantitative analysis of vein quartz using LIBS and chemometric techniques

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Abstract. Vein quartz often becomes the subject of chemical analysis. Laser-induced breakdown spectroscopy (LIBS) is more rapid, cost-effective, and environmentally friendly than traditional silicate analysis. This study demonstrates the feasibility of using LIBS in combination with design of experiment and chemometric methods for the classification analysis of amorphous quartz and the quantitative determination of several constant impurities. The combination of objects and methods used in this work has not been previously published. Vein quartz samples were collected from various geographically distant locations. The sample preparation for LIBS involved cutting and polishing a flat surface of the quartz specimen. The LIBS instrument settings were optimised using design of experiment method. The concentrations of several trace elements in the training and control sets of samples were determined using atomic absorption spectroscopy (AAS). The spectra and analytical data of the training set were used for multivariate calibration using Partial Least Squares Regression (PLS-R). Sample classification was performed using Principal Component Analysis (PCA). It was shown that in the score plot in the space of the first three principal components, the samples confidently group according to their sources of origin. The results were validated on a test set of samples. The accuracy of quantitative determination of Mg, Ca, Na, K, Al, Ti using LIBS exceeded 90%. A method for the quantitative determination of several elements in quartz and an approach to identifying the place of origin of a sample are proposed.

Keywords: vein quartz, laser induced breakdown spectroscopy (LIBS), mathematical design of experiment, partial least squares regression (PLSR), principal component analysis (PCA), atomic absorption spectroscopy (AAS), silicate analysis

Introduction

Due to its frequent use in various economic activities, vein quartz often becomes the subject of various examinations. The chemical analysis of quartz generally involves determination of its chemical composition using silicate analysis techniques [1]. This includes dissolving samples with hydrofluoric acid, removing silicon as SiF₄, and subsequently quantifying trace elements. In modern analysis, atomic spectroscopy is often applied to the solutions for quantitative analysis [2]. Overall, this process is characterised by the use of a toxic reagent – HF, as well as significant duration and labor intensity. Therefore, the improvement of quartz analysis methods is of undeniable interest.

Since 1996 [3], attempts have been made to use LIBS for the analysis of various quartz types. This has shown that the method can be used to detect minor components in minerals and to characterise their qualitative composition [4]. The qualitative and quantitative determination of components by LIBS is useful for both characterization and classification of various minerals by required parameters [5]. This method is still being used in modern researches and was successfully applied to the determination of rare earth elements and other impurities in minerals [6].

There is a mention of the application of LIBS in astronomy and astrobiology for the analysis of various rocks and minerals on the surface of Mars. This has led to new insights into the complex geological history of the planet [7], as well as the information of the potential differentiation between biotic and abiotic signals used in the search for biosignatures on Mars [8].

There is also a necessity for the preliminary analysis of quartz raw materials on the manufactures of quartz products. For instance, CF-LIBS has been applied to the analysis of quartz sand used in glass production, accurately determining the components content in the raw material [9]. Additionally, this method has been used to analyse the composition of atmospheric aerosols on quartz filters [10].

Mathematical processing of spectra becomes more straightforward and simpler with the proper selection of spectrum registration modes. Optimization of the settings of various physico-chemical analysis instruments using design of experiment is currently a recommended practice, included in measurement procedures and standards. Previously [11,12], we demonstrated that probabilistic-deterministic design of experiment (PDDoE) [13] allows for the optimization of LIBS instrument settings under classical calibration conditions, where the goal of optimization is to maximise the intensity of specific analytical lines.

The analysis of quartz and quartz products remains a relevant topic, as the characterization and classification of minerals are essential in many fields of production and science. LIBS has proven to be a promising method for this task due to its rapid and straightforward multi-element analysis.

Hypothesis

By additional application of multivariate calibration methods coupled with LIBS parameters optimization by PDDoE, reliable and accurate results in the classification and characterization

of quartz rocks can be achieved. The Partial Least Squares Regression (PLS-R) chemometric method aids in extracting the most informative and qualitative information from the spectral data obtained through LIBS analysis.

Methodology

Quartz vein samples were randomly collected from various deposits in the Karaganda region. Figures 1 and 2 show examples of such deposits.



Figure 1. Quartz deposits, from left to right: Tokyrau-1, East Konyrat-2, East Konyrat-3

The sample preparation for LIBS involved cutting and polishing a flat surface of the quartz specimen in the Laboratory of Technological Research at "Tsentrgeolanalit" LLC under the supervision of O.V. Kovalenko. LIBS spectra were recorded using the "LAES Matrix Continuum" instrument (Russia, "Spectroscopic Systems" LTD, 2016). The identification of analytical lines utilised the instrument software and the NIST database [14]. Instrument settings, such as lamp energy, timing of the first and second Q-switch modulators, delay, and overall exposure duration were optimised for the maximum average intensity of all analytical lines in the spectrum of one randomly selected quartz sample. A six-factor design with five levels of variation was used for the optimization by the PDDoE method. Calculations were performed using a specially developed program (Auth. Cert. RK No. 26 dated 01.10.2018). After selecting and verifying the optimal instrument settings, five samples from each deposit were used to record spectra. Some quartz specimen with LIBS impact-points are shown at the figure 2. Each sample's spectrum was recorded five times (at different points), and the resulting spectra were averaged by intensity. The averaged spectra were then used for training PLS-R model and classification using PCA. The software «The Unscrambler X» v.10.4 and the R environment [15] were used at this stage.

The dimensionality of the data was reduced using PCA, and a score plot in the space of the first three principal components was used to establish the possibility of classification.



Figure 2. Quartz specimen with LIBS impact-points

Concentrations of several trace elements in the training set were determined by AAS using a Varian AA140 instrument (USA, 2008). After the training of the PLS-R model, it was used to determine the concentrations of trace elements in the test set of samples. The obtained data was verified by AAS in triplicate, followed by an evaluation of measurement errors.

Results and Discussion

The parameters chosen for optimization were those most significantly affecting the quality of the spectrum. The range of their variation was selected based on previous experience [11,12]. The values used are presented in Table 1.

Table 1. The values of used LIBS parameters

Factor	Label	Level 1	Level 2	Level 3	Level 4
EL, J	X_1	14	16	18	20
QSW1, μs	X_2	100	120	150	180
\otimes QSW, μs	X_3	1	3	5	10
D, μs	X_4	1	2	3	5
Expos, ms	X_5	1	2	5	10

The optimised factor was the average intensity of all lines in the spectrum exceeding the background noise level. Significant dependencies were found on the energy of the lamp and the delay time of the first Q-switch modulator (Figure 3).

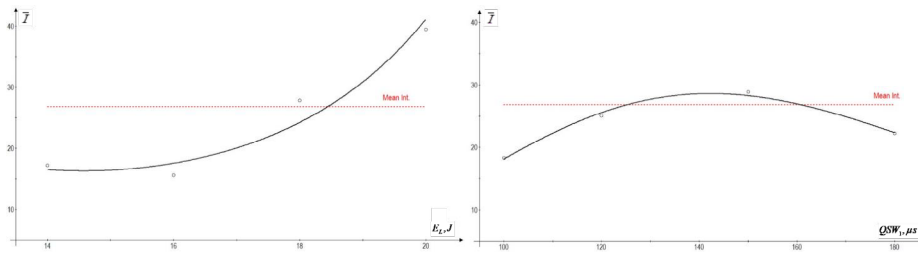


Figure 3. Partial dependencies of the average intensity on lamp energy and QSW1

The generalised equation, obtained using geometric averaging, is characterised by not impressive but sufficient for practical purposes values of $R=0.591$ and $t_R=3.27$:

$$\bar{I} = \frac{20810000000000e^{1.139X_1} X_1^{-16.6} \cdot 2.181 \cdot 10^{-13} e^{-0.05775X_2} X_2^{8.214}}{23.3029}$$

The model was validated by the registration of the spectrum of a sample in five iterations, under conditions predicted by the calculation according to the generalised equation: $E_L=20$ J, $QSW_1=140$ μ s. The mean intensity, with reference to Student's coefficient (5 iterations, $p=0.95$), was 43.4 ± 4.43 .

The spectra of all quartz samples (3-6 from each deposit) were recorded at $E_L=20$ J, $QSW_1=140$ μ s in five iterations, averaged, and normalised. After this, the principal component values were calculated. The first seven principal components describe more than 99% of the variability, which is quite sufficient for any practical needs. The plot of sample positions in the space of the first three principal components is of particular interest (Figure 4):

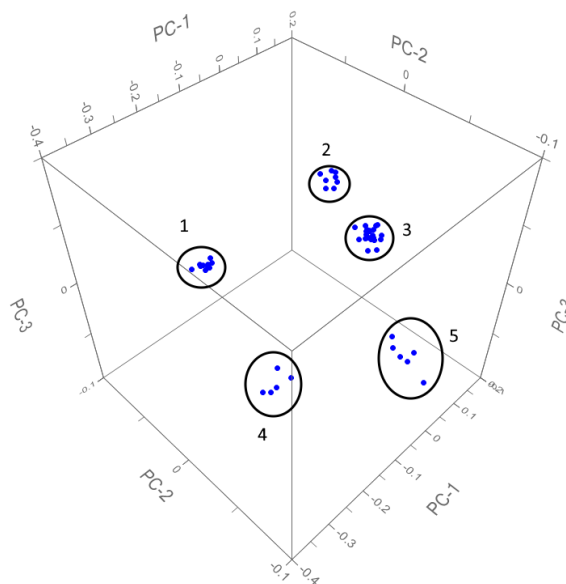


Figure 4. Grouping of the samples in the PC-1:PC-3 space

Geographically, and apparently mineralogically, similar samples were grouped together: 1 – Basaga village and Aktoky hill, 2 – Tegishzhok station and Aktas settlement, 3 – all samples from Eastern Konyrat, Tokyrau, Aktogay, 4 – samples from Ural, 5 – Zhanaarka. This tendency to cluster suggests a successful classification. For more thorough discrimination, Mahalanobis distance assessment /16/ in more than three-dimensional space and with a significantly larger number of samples is needed, but successful classification seems quite likely.

This same set of spectra was used to develop a quantitative analysis method. 4-6 quartz samples, from those for which LIBS spectra were recorded, were analysed using the classical method – dissolution in HF, distillation of SiF₄, and subsequent analysis of the obtained solutions using AAS to determine the content of Mg, Ca, Na, K, Al, Ti. One sample from each deposit was included in the test set, while the spectra and results of the silicate analysis of the remaining samples were used as a training data set for PLS-R. The quality of the model was evaluated using cross-validation. Figure 5 illustrates the quality assessment of one of the calibrations (sodium).

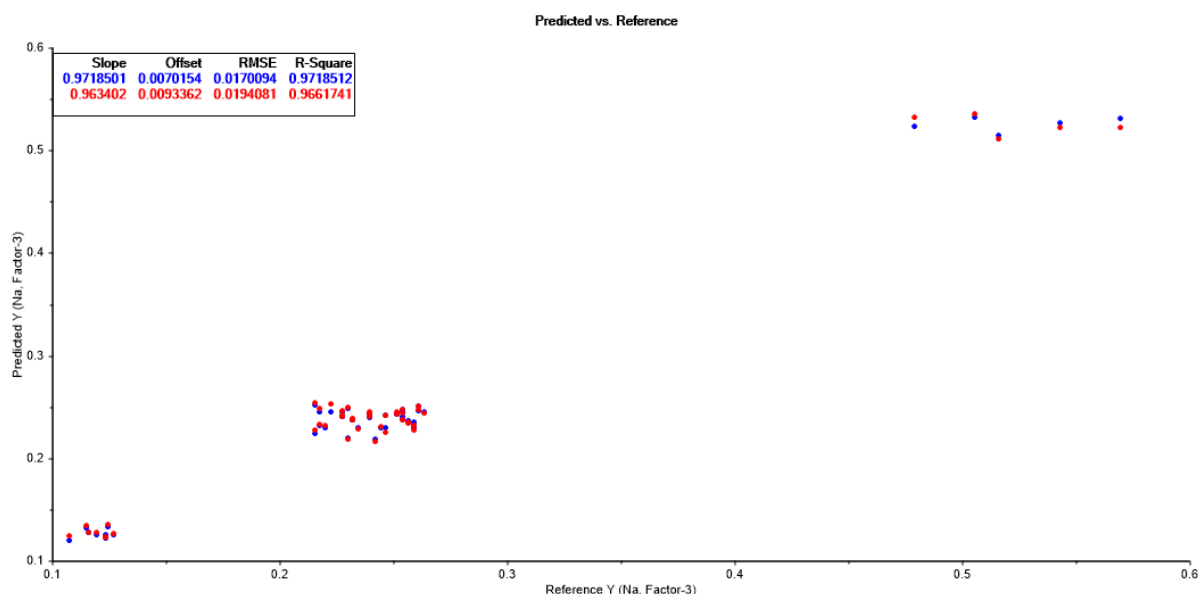


Figure 5. Results of model training for quantitative determination of sodium

Table 2 presents the results of the quantitative determination of several elements in quartz samples from the test set using AAS and LIBS methods. The confidence interval was determined traditionally regarding the Student's coefficient of 2.776 for 5 iterations (4 degrees of freedom) and a confidence probability of 0.95. In most cases, the confidence intervals overlap, and the concentrations are of the same order of magnitude in all cases.

According to Table 2, the results of the determination by the LIBS method are less accurate (as expected), but for most applications, their accuracy is sufficient. The wide confidence interval is compensated by the simplicity of sample preparation. It should be noted that the AAS results are also characterised by relatively large confidence intervals, primarily due to the inability to homogenise with a limited number of samples.

Conclusion

It can be concluded that the combination of LIBS with PLS-R is quite suitable for the quantitative determination of Mg, Ca, Na, K, Al, and Ti in vein quartz. The relative error of determination was (mg/g) 0.1821 ± 0.0519 for Mg, 0.1662 ± 0.0543 for Ca, 0.1646 ± 0.0490 for Na, 0.1842 ± 0.0534 for K, 0.1356 ± 0.0522 for Al and 0.1752 ± 0.0283 for Ti. The proposed quantitative analysis method is accurate and satisfactory for atomic-emission methods and can be used in the daily practice of analytical laboratories. Classification analysis for assigning the place of origin using the principal component method or related methods appears to be a promising direction for further research. A confident separation of quartz samples into groups by place of origin in the space of the first three principal components was achieved, allowing for the development of a convenient classification analysis method.

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The authors confirm that there was no conflict of interest during the study.

Authors' contributions.

Fomin V.N. – Collection of samples, general editing of the article, calculations.

Aldabergenova S.K. – Editing the article, work on the laser-induced breakdown spectrometer, calculations.

Kelesbek N.K. – Collection of samples, work on the work on the laser-induced breakdown spectrometer, sample preparation for the atomic absorption spectrometer.

Kaykenov D.A. – Work on the atomic absorption spectrometer, sample preparation for the atomic absorption spectrometer, calculations.

Turovets M.A. – selection of literature, work on the laser-induced breakdown spectrometer, calculations.

Table 2. Results of the quantitative determination of elements in quartz samples from the test set using AAS and LIBS methods

	Mg, mg/g		Ca, mg/g		Na, mg/g		K, mg/g		Al, mg/g		Ti, mg/g	
	LIBS	AAS	LIBS	AAS	LIBS	AAS	LIBS	AAS	LIBS	AAS	LIBS	AAS
1 1VosKon.test	0.0137 ±0.002	0.0141 ±0.001	0.0131 ±0.003	0.0132 ±0.001	0.2308 ±0.051	0.2851 ±0.0155	0.0639 ±0.013	0.7993 ±0.032	0.0720 ±0.008	0.0794 ±0.004	0.0137 ±0.002	0.0097 ±0.001
2 2VosKon.test	0.0149 ±0.003	0.0125 ±0.001	0.0112 ±0.002	0.0071 ±0.0008	0.2352 ±0.0009	0.1563 ±0.004	0.0665 ±0.011	0.0803 ±0.004	0.0627 ±0.011	0.0778 ±0.006	0.0125 ±0.002	0.0011 ±0.0001
3 3VosKon.test	0.0140 ±0.003	0.0172 ±0.002	0.0123 ±0.001	0.0141 ±0.001	0.2308 ±0.0032	0.2586 ±0.0143	0.0733 ±0.006	0.0691 ±0.003	0.0674 ±0.013	0.055 ±0.013	0.0138 ±0.003	0.0124 ±0.001
4 AktasTest	0.0309 ±0.014	0.043 ±0.004	0.0112 ±0.002	0.0144 ±0.0009	0.1120 ±0.0026	0.133 ±0.015	0.0665 ±0.014	0.0558 ±0.004	0.0647 ±0.008	0.0572 ±0.002	0.0139 ±0.003	0.0152 ±0.0008
5 Aktogai Test	0.0139 ±0.002	0.0168 ±0.002	0.0165 ±0.003	0.0218 ±0.002	0.1975 ±0.0012	0.0842 ±0.004	0.0699 ±0.012	0.082 ±0.009	0.0687 ±0.003	0.0672 ±0.002	0.0135 ±0.002	0.0129 ±0.001
6 AktokyTest	0.0129 ±0.003	0.0153 ±0.001	0.0113 ±0.002	0.0125 ±0.001	0.2384 ±0.002	0.2501 ±0.011	0.0618 ±0.012	0.0885 ±0.006	0.1408 ±0.008	0.1396 ±0.002	0.0125 ±0.0021	0.0153 ±0.001
7 BosagaTest	0.0120 ±0.0023	0.0177 ±0.0008	0.0131 ±0.003	0.0073 ±0.0007	0.2374 ±0.001	0.2869 ±0.011	0.0605 ±0.016	0.07 ±0.007	0.1312 ±0.026	0.0962 ±0.0012	0.0133 ±0.0021	0.016 ±0.001
8 TegisjolTest	0.0308 ±0.007	0.0378 ±0.0012	0.0118 ±0.001	0.0125 ±0.001	0.1209 ±0.0028	0.0105 ±0.017	0.0672 ±0.006	0.0633 ±0.003	0.0641 ±0.011	0.074 ±0.007	0.0117 ±0.002	0.0141 ±0.001
9 TokTest	0.0147 ±0.003	0.0115 ±0.0009	0.0124 ±0.001	0.0112 ±0.001	0.2330 ±0.002	0.1773 ±0.0105	0.0706 ±0.014	0.084 ±0.008	0.0720 ±0.01	0.08 ±0.008	0.0143 ±0.0023	0.0208 ±0.002
10 UralTest	0.0312 ±0.007	0.0483 ±0.005	0.0159 ±0.003	0.0147 ±0.0008	0.4427 ±0.0025	0.608 ±0.0134	0.1343 ±0.032	0.1592 ±0.005	0.1284 ±0.024	0.1255 ±0.002	0.0265 ±0.006	0.032 ±0.003
11 ZhanarkaTest	0.0137 ±0.002	0.0141 ±0.001	0.0131 ±0.003	0.0132 ±0.001	0.2308 ±0.051	0.2851 ±0.0155	0.0639 ±0.013	0.7993 ±0.032	0.0720 ±0.008	0.0794 ±0.004	0.0137 ±0.002	0.0097 ±0.001
PLSR R-square	0.93849		0.78849		0.96617		0.84396		0.93822		0.88657	

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LIBS және хемометриканы қолданып кварцты жіктеу және сандық талдау әдісі

Андатпа. Желілік кварц химиялық талдау объектісі ретінде жиі қолданылады. Лазерлік атомды-эмиссиялық спектроскопия дәстүрлі силикаттық талдаудан жылдамырақ, арзанырақ және экологиялық таза. Жұмыста аморфты кварцты жіктеу талдауы және бірқатар тұрақты қоспаларды сандық анықтау үшін тәжірибені жоспарлау және химометриялық әдістерімен бірге LIBS қолдану мүмкіндігі көрсетілген. Жұмыста қолданылатын әдістер объектілерінің тіркесімі бұрын жарияланбаған. Негізгі кварц үлгілері әртүрлі, географиялық жағынан бір-бірінен алыс жерлерден алынды. LIBS үшін кварцты сынама дайындау тегіс бетті кесу және тегістеу арқылы жүргізілді. LIBS құрылғысының параметрлері экспериментті математикалық жоспарлауды қолдана отырып оңтайландырылды. Үлгілердің оқыту және бақылау жиынтығындағы бірқатар қоспа элементтерінің концентрациясы AAS қолдану арқылы анықталды. PLSR әдісімен көпөлшемді калибрлеу үшін оқу жиынтығының спектрлері мен талдау деректері пайдаланылды. Үлгілерді жіктеу PCA көмегімен жүзеге асырылды. Алғашқы үш негізгі компоненттің кеңістігіндегі есеп кестесі бойынша үлгілер шығу көздеріне байланысты сенімді түрде топтастырылатындығы көрсетілген. Нәтижелер үлгілердің сынақ жинағында тексерілді. LIBS көмегімен Mg, Ca, Na, K, Al, Ti сандық дәлдігі 90%-дан асты. Кварцтағы бірқатар элементтерді сандық анықтау әдісі және үлгінің шыққан жерін анықтау тәсілі ұсынылған.

Түйін сөздер: желілік кварц, лазерлік атомды – эмиссиялық спектроскопия (LIBS), экспериментті математикалық жоспарлау, жасырын құрылымдарға регрессия (PLSR), негізгі компоненттер әдісі (PCA), атомды-абсорбциялық спектроскопия (AAS), силикатты талдау.

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Метод классификационного и количественного анализа жильного кварца с применением LIBS и хемометрики

Аннотация. Жильный кварц часто становится объектом химического анализа. Лазерная атомно-эмиссионная спектроскопия быстрее, дешевле и экологичнее традиционного силикатного анализа. В работе показана возможность использования LIBS в сочетании с

планированием эксперимента и хемометрическими методами для классификационного анализа аморфного кварца и количественного определения ряда постоянных примесей. Используемое в работе сочетание объектов методов ранее не публиковалось. Образцы жильного кварца были отобраны из разных, географически удаленных друг от друга, мест. Пробоподготовка кварца для LIBS проводилась распилом и шлифовкой плоской поверхности. Настройки прибора LIBS оптимизировали с применением математического планирования эксперимента. Концентрации ряда элементов-примесей в обучающем и контрольном наборах образцов определяли с применением AAS. Спектры и данные анализа обучающего набора использовали для многомерной калибровки методом PLSR. Классификацию образцов проводили с помощью PCA. Показано, что по графику счетов в пространстве первых трёх главных компонент образцы уверенно группируются по источникам происхождения. Результаты проверяли на тестовом наборе образцов. Точность количественного определения Mg, Ca, Na, K, Al, Ti с применением LIBS превысила 90%. Предложен метод количественного определения ряда элементов в кварце и подход к определению места происхождения образца.

Ключевые слова: жильный кварц, лазерная атомно-эмиссионная спектроскопия (LIBS), математическое планирование эксперимента, регрессия на латентные структуры (PLSR), метод главных компонент (PCA), атомно-абсорбционная спектроскопия (AAS), силикатный анализ.

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Navigating the Future of Chemistry: Priorities and Opportunities for Sustainable Innovation (review)

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Abstract. The essay explores the shifting landscape of energy and chemical production, focusing on the growing emphasis on sustainability over the last decade. It highlights key research areas that have gained substantial attention, such as biorefineries, solar energy conversion, energy storage materials, and carbon dioxide utilization. The authors stress the need for innovative solutions in catalysis, process design, and the use of alternative raw materials and energy sources. They advocate for a more comprehensive view of sustainability, considering both economic and socio-environmental factors, and encourage a forward-looking approach to address future trends and challenges. This analysis aims to motivate researchers and industry players to pursue new technologies and methods that will drive a more sustainable future in the fields of chemistry and energy.

Keywords: Sustainability, Biorefinery, Solar energy conversion, Energy storage, Carbon dioxide utilization, Catalysis, Circular economy, Renewable resources.

Introduction

The global energy and chemical production landscape is experiencing a significant shift, driven by the urgent need for sustainability and the potential of emerging technologies. As we confront the challenges of climate change, resource depletion, and environmental harm, the chemical industry finds itself at a pivotal moment. The shift from fossil fuel-based processes to more sustainable practices is not just a passing trend but a crucial necessity for the future of our planet [1]. This essay explores the priorities and opportunities presented by this transition, focusing on sustainability and the key advancements made in the past decade [2].

Traditionally, the chemical industry has been fundamental to economic growth, supplying vital materials and energy across sectors. However, conventional production methods have come with considerable environmental costs, including greenhouse gas emissions and ecological damage. The need for a fundamental shift is emphasized by growing societal demand for sustainable solutions and the realization that current practices are unsustainable. Moving forward, a comprehensive approach is essential, integrating sustainability into all aspects of chemical production—from sourcing raw materials to final applications [3,4].

Global greenhouse gas emissions have reached record levels, increasing by 1.3% in 2020, exacerbating the climate crisis (Figure 1).

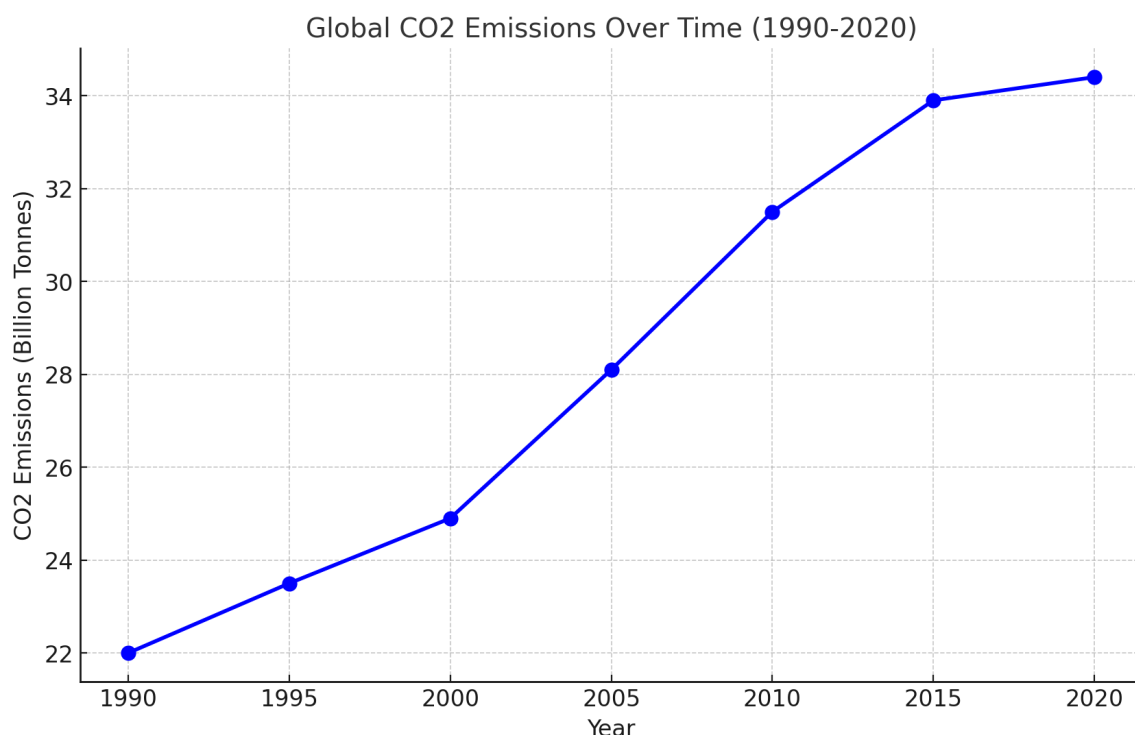


Figure 1. Solar reforming as an emerging technology for circular chemical industries

Scarcity of natural resources such as fossil fuels is exacerbated by growing demand, while the extraction and processing of raw materials is becoming increasingly costly and environmentally hazardous [5–7]. Social demand for environmentally friendly products is also increasing: according to surveys, more than 70% of global consumers prefer sustainably produced goods. At the same time, governments are tightening regulations to reduce emissions and implement environmentally friendly technologies, which requires companies to find new,

cleaner and more efficient production methods, such as recycling waste and raw materials using pyrolysis [8,9].

One of the most promising strategies for promoting sustainability in the chemical industry is the use of renewable resources. Biomass, for example, provides a renewable alternative to fossil fuels, allowing the production of chemicals and fuels through biorefinery methods [5]. This not only lessens dependence on limited resources but also supports carbon neutrality by absorbing CO₂ from the atmosphere. Advances in lignin conversion technologies and the development of platform molecules are driving more efficient and sustainable biomass utilization [10]. The potential for biomass to serve as a key feedstock in the chemical industry is immense, and continued research is essential to fully realize its benefits.

Alongside biomass, solar energy presents another major opportunity for sustainable chemical production. Progress in materials for solar energy conversion, such as photocatalysts and solar cells, has accelerated in recent years [11]. These technologies allow sunlight to be directly converted into chemical energy, providing a clean and renewable power source. Cutting-edge research in artificial photosynthesis and water splitting is focused on replicating natural processes to sustainably produce fuels and chemicals [12]. By incorporating solar energy into chemical production, we can decrease reliance on fossil fuels and reduce the environmental impact of conventional methods [13].

Energy storage is a crucial element in the transition to a sustainable chemical industry. As renewable energy sources become more widespread, the demand for efficient storage solutions grows [14]. Advances in battery technologies, fuel cells, and supercapacitors are key to enabling the broad adoption of renewable energy. In this study, we conducted a thorough analysis of these technologies, employing specific criteria such as efficiency, capacity, and sustainability to evaluate their effectiveness. We selected relevant research based on their contributions to these criteria, ensuring a robust overview of current advancements in the field [15].

Materials and methods

The development of new materials and technologies for energy storage will be central to the future of sustainable chemistry. Additionally, utilizing carbon dioxide as a raw material offers a unique solution to both energy production and greenhouse gas reduction [16]. CO₂ utilization technologies seek to transform waste CO₂ into valuable chemicals and fuels, effectively closing the carbon loop. This approach not only helps combat climate change by lowering atmospheric CO₂ levels but also creates new avenues for chemical production. Rapid advancements in catalytic processes are making it possible to convert CO₂ into a variety of products, from fuels to polymers. We employed standardized criteria to evaluate the effectiveness of these catalytic processes, allowing us to compare their performance with existing methods. Integrating CO₂ utilization into the chemical industry marks a significant step toward achieving a circular economy [17].

While advancements in biomass utilization, solar energy conversion, energy storage, and CO₂ utilization are encouraging, sustainability extends beyond technological innovation. A holistic approach to sustainable chemistry must also address economic and socio-environmental considerations [18]. The shift to a sustainable chemical industry requires cooperation among researchers, industry leaders, and policymakers to create a supportive environment for innovation. This includes establishing favorable regulatory frameworks, fostering public-private partnerships, and investing in education and training to prepare the workforce for future challenges.

Additionally, the role of catalysis in advancing sustainability is of critical importance. Catalysis is a key technology that improves the efficiency and selectivity of chemical processes.

In our review, we provide a detailed comparison of new catalysts, both homogeneous and heterogeneous, highlighting how their innovations surpass existing technologies [19]. This discussion illustrates the ways in which new catalysts contribute to more sustainable practices by enabling reactions to occur under less extreme conditions, thus lowering energy consumption and reducing waste production. Therefore, continued research in catalysis is vital to fully realizing the potential of sustainable chemistry [20].

The future of chemistry is closely tied to the pursuit of sustainability. The shift from conventional fossil fuel-based methods to innovative, sustainable practices presents both challenges and opportunities [21]. By adopting renewable resources, utilizing solar energy, enhancing energy storage systems, and converting CO₂ into useful products, the chemical industry can play a key role in addressing global energy and environmental issues. However, achieving true sustainability requires a comprehensive approach that combines technological advancements with economic and socio-environmental considerations.

Reflecting on the progress made over the past decade, moving forward will demand ongoing investment in research, collaboration, and a steadfast commitment to fostering a sustainable future for both the chemical industry and the broader world. The aim of this study is to analyze the current state of research and assess the prospects of state-of-the-art technologies and practices that promote sustainability in the fields of chemistry and energy. The authors emphasize the significance of innovative solutions in areas such as bioprocessing, solar energy conversion, energy storage, and carbon dioxide utilization, while advocating for a comprehensive approach to sustainability that considers economic, social, and environmental aspects.

Results and discussion

The sustainable future of chemicals and energy is a critical area of focus as the world grapples with the dual challenges of climate change and resource scarcity. The chemical industry is responsible for approximately 10% of global greenhouse gas emissions, contributing significantly to climate change. In 2021 alone, the sector emitted over 1.2 billion tons of CO₂ in the U.S. [17]. This transformation is not only essential for environmental preservation but also presents a wealth of opportunities for innovation, economic growth, and societal well-being.

At the heart of a sustainable future for chemicals and energy lies the concept of a circular economy. Unlike the traditional linear model of production and consumption, which often leads to waste and environmental degradation, a circular economy emphasizes the continual use of resources. This model encourages the design of products and processes that minimize waste, promote recycling, and facilitate the reuse of materials. For instance, plastic waste is projected to triple by 2040 if current trends continue, highlighting the urgent need for innovative waste management strategies. In the chemical industry, this means developing processes that not only reduce the consumption of raw materials but also enable the recovery and repurposing of by-products [22,23]. The integration of waste-to-chemical processes can convert industrial waste into valuable feedstocks, thus closing the loop and reducing reliance on virgin materials. For example, companies like LanzaTech have successfully transformed industrial emissions into ethanol, demonstrating the viability of this approach [24].

Another promising avenue for achieving a sustainable future in the chemical sector is the utilization of renewable feedstocks. Biomass, for example, offers a renewable alternative to fossil fuels, allowing for the production of chemicals and fuels through biorefinery processes. It is estimated that biomass could meet up to 30% of global energy needs by 2030 [25]. Advances in biotechnology and enzymatic processes are enabling the efficient conversion of biomass into platform chemicals, which can serve as building blocks for a wide range of products. For

instance, companies like Novozymes are developing enzymes that can convert agricultural residues into bio-based chemicals. By shifting towards renewable feedstocks, the chemical industry can significantly reduce its carbon footprint and contribute to a more sustainable energy landscape.

In addition to these industrial efforts, numerous scientists and researchers are making significant contributions to this field. Notable figures include Professor Sir Richard Friend from the University of Cambridge, who has conducted groundbreaking research on organic photovoltaics, aiming to improve solar energy efficiency for chemical processes [26]. His work is crucial in enhancing the sustainability of energy sources used in chemical synthesis.

Another key researcher is Dr. Jennifer A. Doudna, a pioneer in CRISPR technology, who is exploring its applications in bioengineering to optimize microorganisms for biofuel production [27]. Her innovative approach could lead to more efficient conversion processes, thereby supporting the chemical industry's shift toward renewable resources.

By shifting towards renewable feedstocks and embracing innovative practices, the chemical industry can significantly reduce its carbon footprint and contribute to a more sustainable energy landscape. These collaborative efforts among scientists, researchers, and industry leaders underscore the critical importance of interdisciplinary approaches in tackling the challenges of sustainability [28].

The urgency of this transition is further underscored by growing regulatory pressures and consumer demand for eco-friendly products. Recent studies show that 75% of consumers are willing to pay more for sustainable products, pushing companies to adopt greener practices. Additionally, international regulations, such as the European Green Deal, set ambitious targets for reducing emissions and promoting sustainable industry practices, necessitating a rapid shift in how chemicals are produced and used [29].

Statistics also reveal the economic imperative for sustainable practices. The global market for green chemicals is projected to reach \$1 trillion by 2027, growing at a CAGR of over 10%. This shift not only highlights the increasing consumer preference for sustainable products but also signals a significant economic opportunity for companies that invest in sustainable technologies and practices. Furthermore, transitioning to a circular economy could save the global economy approximately \$4.5 trillion by 2030 through improved resource efficiency and reduced waste, demonstrating that sustainability is not only an environmental imperative but also a pathway to economic resilience and growth [6].

These factors collectively highlight the critical need for a sustainable transformation in the chemical industry, making it essential to invest in innovative technologies and frameworks that support this transition.

In addition to biomass, the utilization of carbon dioxide (CO₂) as a raw material presents a unique opportunity for sustainable chemical production. CO₂ utilization technologies aim to convert waste CO₂ into valuable chemicals and fuels, effectively addressing both energy production and greenhouse gas emissions. This approach not only helps mitigate climate change by reducing atmospheric CO₂ levels but also creates new pathways for chemical production [30,31]. Research in this field is rapidly advancing, with promising developments in catalytic processes that enable the conversion of CO₂ into a range of products, from fuels to polymers. The integration of CO₂ utilization into the chemical industry represents a significant step towards achieving a circular economy and reducing the environmental impact of chemical production [32].

The role of renewable energy sources in the sustainable future of chemicals cannot be overstated. The transition from fossil fuels to renewable energy sources, such as solar, wind, and hydropower, is essential for reducing the carbon intensity of chemical production. The development of materials for solar energy conversion, such as photocatalysts and solar cells, has gained momentum in recent years. These technologies enable the direct conversion of

sunlight into chemical energy, offering a clean and renewable source of power [33–35]. Innovations in artificial photosynthesis and water splitting are at the forefront of this research, aiming to mimic natural processes to produce fuels and chemicals sustainably. By integrating renewable energy into chemical production, we can significantly reduce our dependence on fossil fuels and mitigate the environmental impact of traditional processes [36].

Energy storage is another critical component of the sustainable future of chemicals and energy. As renewable energy sources become more prevalent, the need for efficient energy storage solutions is paramount. Advances in battery technology, fuel cells, and supercapacitors are essential for enabling the widespread adoption of renewable energy. Research in this area focuses on improving the efficiency, capacity, and sustainability of energy storage systems, ensuring that energy generated from renewable sources can be effectively utilized when needed. The development of new materials and technologies for energy storage will play a pivotal role in the future of sustainable chemistry [37].

Moreover, the importance of catalysis in promoting sustainability cannot be overstated. Catalysis serves as a key enabling technology that enhances the efficiency and selectivity of chemical processes. The development of new catalysts, both homogeneous and heterogeneous, is crucial for driving the transition to more sustainable practices [11,38,39]. Catalysts can facilitate reactions under milder conditions, reduce energy consumption, and minimize waste generation. As such, ongoing research in catalysis is essential for unlocking the full potential of sustainable chemistry.

Collaboration among stakeholders is vital for realizing a sustainable future in chemicals and energy. This includes partnerships between academia, industry, and government to foster innovation and create supportive regulatory frameworks. Policymakers play a crucial role in establishing incentives for sustainable practices, such as tax breaks for companies that invest in renewable technologies or grants for research in sustainable chemistry [40]. Additionally, public-private partnerships can facilitate the sharing of knowledge and resources, accelerating the development and implementation of sustainable technologies.

Education and training are also essential components of a sustainable future. As the chemical industry evolves, the workforce must be equipped with the skills and knowledge necessary to navigate this transition. Educational institutions should prioritize sustainability in their curricula, fostering a new generation of scientists and engineers who are well-versed in sustainable practices and technologies. Furthermore, ongoing professional development opportunities for current industry professionals will ensure that the workforce remains adaptable and capable of meeting the challenges of a rapidly changing landscape [3].

Outlining a sustainable future for chemicals and energy requires a multifaceted approach that encompasses innovative technologies, collaborative efforts, and a commitment to circular economy principles. By embracing renewable feedstocks, utilizing CO₂ as a raw material, integrating renewable energy sources, and advancing energy storage solutions, the chemical industry can significantly reduce its environmental impact and contribute to a more sustainable energy landscape [41]. The role of catalysis, collaboration among stakeholders, and education will be pivotal in driving this transition. As we move forward, it is essential to recognize that the path to sustainability is not only a necessity but also an opportunity for innovation, economic growth, and a healthier planet for future generations [42].

In recent years, significant achievements have been made in the field of sustainable development within the chemical industry and energy sector, reflecting a growing awareness of the need to transition to more environmentally friendly practices. One major advancement is the development of new biotechnologies that enable the efficient conversion of agricultural waste and other renewable resources into valuable chemicals. Companies like LanzaTech and Novozymes have pioneered processes that utilize microorganisms to transform carbon dioxide and biomass into useful products, including biofuels and biochemical [24,43].

Additionally, there has been an increase in the number of chemical companies implementing recycling technologies. For instance, BASF and Dow are actively working on processes that convert plastic waste into new raw materials, contributing to a circular economy and reducing the need for virgin resources. The development of bioplastics and biodegradable materials, such as polylactic acid (PLA), represents another important step in minimizing environmental impact, with these materials being utilized in packaging and various industries to provide more sustainable solutions [29]. The implementation of advanced technologies and processes, such as catalytic reactors and energy-efficient systems, has allowed many chemical plants to significantly reduce energy consumption and lower greenhouse gas emissions. Companies like SABIC and Shell have adopted carbon capture and storage (CCS) solutions, which substantially decrease their carbon footprint. Many organizations are also beginning to develop circular economy strategies where waste is converted into new products. For example, Unilever has announced plans to make all its packaging materials recyclable or reusable by 2025, demonstrating a strong commitment to sustainability.

These achievements highlight that the chemical industry is moving toward a more sustainable future by actively embracing innovation and adapting to the evolving demands of the market and society.

Solar-Driven Chemistry

As the world grapples with the pressing challenges of climate change and resource depletion, the need for innovative solutions in energy production and chemical synthesis has never been more urgent. Solar-driven chemistry emerges as a transformative approach that harnesses the abundant energy of the sun to drive chemical reactions, offering a pathway toward sustainable practices in the chemical industry. This paradigm shift not only aims to reduce reliance on fossil fuels. It also seeks to minimize greenhouse gas emissions and promote the use of renewable resources [44]. In this exploration of solar-driven chemistry, we will delve into its principles, applications, and the potential it holds for a sustainable future. At its core, solar-driven chemistry leverages solar energy to facilitate chemical transformations. This approach is inspired by natural processes, particularly photosynthesis, where plants convert sunlight, water, and carbon dioxide into glucose and oxygen. By mimicking these processes, researchers aim to develop systems that can convert solar energy into chemical energy, effectively storing it for later use. The fundamental mechanisms involved in solar-driven chemistry include photochemical reactions, photocatalysis, and artificial photosynthesis, each playing a crucial role in the development of sustainable chemical processes [40,45].

Solar-driven chemistry can play a pivotal role in energy storage. As renewable energy sources, such as solar and wind, become more prevalent, the need for efficient energy storage solutions is paramount. Solar-driven chemical processes can convert excess solar energy into chemical fuels, effectively storing energy for later use. This approach not only addresses the intermittency of renewable energy sources but also provides a means to decarbonize sectors that are challenging to electrify, such as heavy industry and transportation [46]. For example, solar-driven processes can produce hydrogen or hydrocarbons that can be stored and utilized as fuels, providing a versatile solution for energy storage and transportation. The work of researchers like Dr. Jennifer A. Doudna also highlights the potential of CRISPR technology in optimizing biological pathways for fuel production, further enhancing the efficiency and sustainability of these processes [27].

Notable researchers in this field include Professor Michael Grätzel from École Polytechnique Fédérale de Lausanne, known for his pioneering work on dye-sensitized solar cells [47]. His research has significantly advanced the efficiency of solar energy capture, laying the groundwork for its application in artificial photosynthesis. Another key figure is Dr. Nathan

S. Lewis from Caltech, who focuses on developing photoelectrochemical systems for solar fuel production [48]. His innovative approaches to integrating catalysts and light-absorbing materials have made strides in improving the efficiency of solar-driven chemical reactions.

In summary, while existing chemical synthesis and energy production methods largely rely on fossil fuels and high-energy inputs, solar-driven chemistry - particularly through photocatalysis and artificial photosynthesis - presents a substantial leap forward. By utilizing renewable solar energy and promoting CO₂ conversion, these technologies represent a significant advancement in our quest for sustainable practices in the chemical industry, aligning more closely with global sustainability goals.

The integration of solar-driven chemistry into the chemical industry holds significant potential for reducing carbon emissions and promoting sustainability. Traditional chemical processes often rely on fossil fuels as both energy sources and feedstocks, contributing to environmental degradation. By shifting to solar-driven methods, the industry can reduce its carbon footprint and transition toward a more sustainable model. For instance, solar-driven processes can be employed in the production of essential chemicals, such as ammonia, which is traditionally produced through energy-intensive Haber-Bosch processes. Researchers are exploring alternative pathways that could significantly lower energy consumption and emissions associated with ammonia production by utilizing solar energy.

Photocatalysis is one of the most promising areas within solar-driven chemistry. It involves the use of light-activated catalysts to accelerate chemical reactions. Photocatalysts can harness sunlight to drive reactions that would otherwise require significant energy input. For instance, titanium dioxide (TiO₂) is a widely studied photocatalyst that can facilitate the degradation of pollutants in water and air when exposed to UV light [49]. More advanced photocatalysts are being developed to enable the conversion of CO₂ into valuable chemicals, such as methanol or hydrocarbons, effectively addressing both energy production and greenhouse gas emissions [50] (Figure 2). This dual functionality positions photocatalysis as a key player in the transition to a low-carbon economy [33].

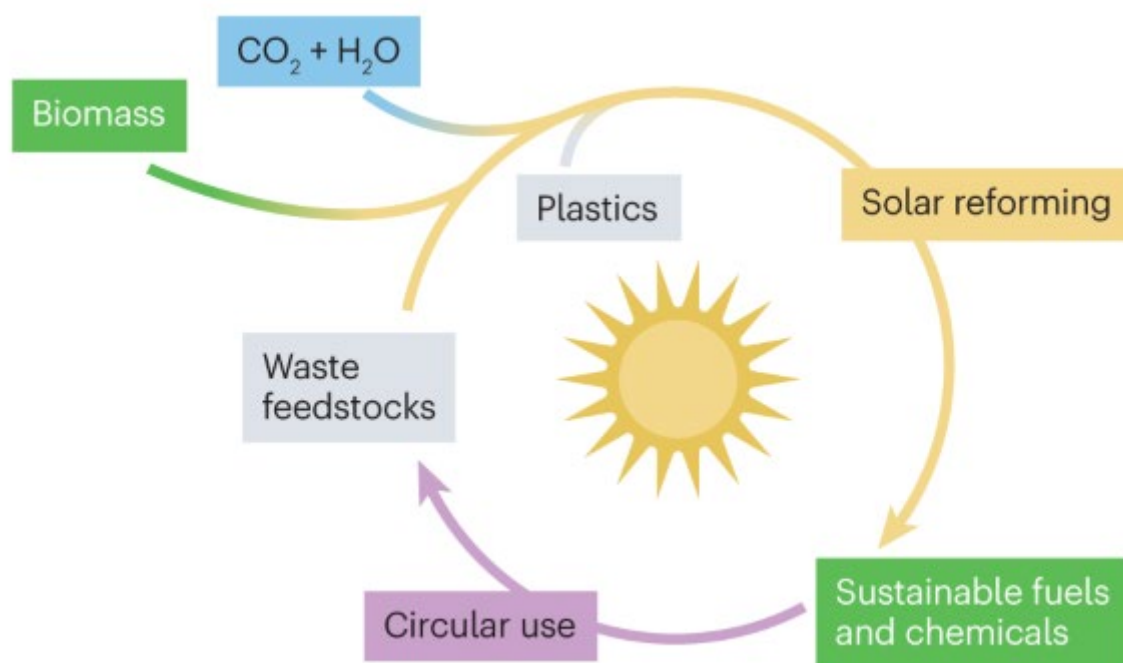


Figure 2. Solar reforming as an emerging technology for circular chemical industries

Artificial photosynthesis represents another exciting frontier in solar-driven chemistry. Researchers are working to create systems that mimic the natural process of photosynthesis, aiming to produce fuels and chemicals directly from sunlight, water, and CO₂. These systems typically consist of light-absorbing materials, catalysts, and reaction chambers designed to optimize the conversion of solar energy into chemical energy. For example, recent advancements in the development of photoelectrochemical cells have shown promise in efficiently converting solar energy into hydrogen fuel through the splitting of water molecules [51]. This hydrogen can then be utilized as a clean energy carrier or as a feedstock for various chemical processes [52].

Artificial Photosynthesis further distinguishes itself from prior methods by directly mimicking the natural process of photosynthesis, which has evolved over millions of years to efficiently harness solar energy [53]. Unlike earlier synthetic methods, which typically involve complex, energy-intensive processes, artificial photosynthesis aims to achieve similar efficiencies with minimal environmental impact. This innovative approach not only enhances energy capture but also integrates carbon sequestration into the chemical synthesis process, promoting sustainability in a way that traditional techniques cannot match [3].

In summary, while existing chemical synthesis and energy production methods are largely reliant on fossil fuels and high-energy inputs, solar-driven chemistry, particularly through photocatalysis and artificial photosynthesis, presents a substantial leap forward. By utilizing renewable solar energy and promoting CO₂ conversion, these technologies represent a significant advancement in our quest for sustainable practices in the chemical industry, aligning more closely with global sustainability goals [16].

The integration of solar-driven chemistry into the chemical industry holds significant potential for reducing carbon emissions and promoting sustainability. Traditional chemical processes often rely on fossil fuels as both energy sources and feedstocks, contributing to environmental degradation. By shifting to solar-driven methods, the industry can reduce its carbon footprint and transition toward a more sustainable model. For instance, solar-driven processes can be employed in the production of essential chemicals, such as ammonia, which is traditionally produced through energy-intensive Haber-Bosch processes. By utilizing solar energy, researchers are exploring alternative pathways that could significantly lower energy consumption and emissions associated with ammonia production. Moreover, solar-driven chemistry can play a pivotal role in energy storage. As renewable energy sources, such as solar and wind, become more prevalent, the need for efficient energy storage solutions is paramount. Solar-driven chemical processes can convert excess solar energy into chemical fuels, effectively storing energy for later use. This approach not only addresses the intermittency of renewable energy sources but also provides a means to decarbonize sectors that are challenging to electrify, such as heavy industry and transportation. For example, solar-driven processes can produce hydrogen or hydrocarbons that can be stored and utilized as fuels, providing a versatile solution for energy storage and transportation [40].

The development of solar-driven chemistry is not without its challenges. One of the primary hurdles is the efficiency of solar energy conversion. While significant progress has been made in recent years, many solar-driven processes still face limitations in terms of efficiency and scalability. Researchers are actively working to improve the performance of photocatalysts and artificial photosynthesis systems, exploring new materials and reaction conditions to enhance energy conversion rates. Additionally, the integration of solar-driven processes into existing industrial frameworks requires careful consideration of economic viability and infrastructure development [54].

Collaboration among academia, industry, and government is essential for advancing solar-driven chemistry. Public-private partnerships can facilitate the sharing of knowledge, resources, and funding, accelerating the development and commercialization of solar-driven

technologies. Furthermore, supportive policies and incentives can encourage investment in research and development, fostering innovation in this field. As the global community increasingly recognizes the importance of sustainability, the potential for solar-driven chemistry to contribute to a low-carbon future is gaining traction. Education and outreach also play a crucial role in promoting solar-driven chemistry [55]. Raising awareness about the benefits and potential applications of solar-driven processes can inspire the next generation of scientists and engineers to pursue careers in this field. Educational institutions should prioritize sustainability in their curricula, equipping students with the knowledge and skills needed to tackle the challenges of the future. Additionally, public engagement initiatives can help foster a broader understanding of the importance of solar-driven chemistry in addressing climate change and promoting sustainable practices [56].

Solar-driven chemistry represents a promising avenue for achieving a sustainable future in energy production and chemical synthesis. By harnessing the power of the sun, this innovative approach has the potential to revolutionize the chemical industry, reducing reliance on fossil fuels and minimizing environmental impact [57]. Through advancements in photocatalysis, artificial photosynthesis, and energy storage, solar-driven chemistry can contribute to a low-carbon economy while addressing the pressing challenges of climate change [58]. As research and development in this field continue to progress, collaboration among stakeholders and a commitment to education will be essential for realizing the full potential of solar-driven chemistry. Embracing this transformative approach is not only a necessity for sustainability but also an opportunity for innovation and economic growth in the years to come [29].

A major plus point of photosynthesis is its role in absorbing carbon dioxide, which helps reduce the concentration of this greenhouse gas in the atmosphere. This makes photosynthesis an important process in the fight against climate change. However, photosynthesis also has its disadvantages [59,60]. Natural photosynthetic systems have a low solar energy conversion efficiency of about 1-2%. This limits their potential application as a direct source of energy for technological needs.

Photocatalysis, on the other hand, is an artificial process that uses light to accelerate a chemical reaction using a photocatalyst. This process is being actively studied for applications such as water purification, separation of water into hydrogen and oxygen, and carbon dioxide utilization. One of the main advantages of photocatalysis is that it can be used to create hydrogen, a clean and renewable fuel. Also, photocatalysis can be used for environmentally friendly processes such as the degradation of pollutants in air and water [56,61,62]. However, photocatalysis also has its limitations. Current photocatalysis technologies often require expensive materials such as titanium or platinum-containing catalysts, which limits their widespread application. In addition, the efficiency of photocatalysis under real-world conditions is sometimes low because strong solar illumination or even ultraviolet radiation is required, limiting its use in sunlight-deficient regions.

If we compare photosynthesis and photocatalysis with other energy conversion technologies, such as solar cells (photovoltaic panels), the latter have a much higher solar energy conversion efficiency of about 15-20% [63,64]. However, solar panels require significant capital investment and cannot directly participate in carbon dioxide conversion or biomolecule synthesis processes, making them less versatile than photocatalysis or photosynthesis [65,66].

Thus, photosynthesis and photocatalysis have their unique advantages related to their environmental friendliness and potential to reduce carbon dioxide concentrations. Nevertheless, their limited efficiency and high material costs make them less attractive compared to conventional energy generation technologies. Nevertheless, active research in

these areas is ongoing, which could lead to significant increases in their efficiency and cost reductions in the future.

Impact of Catalysis

Catalysis plays a pivotal role in the transition toward sustainable chemistry and energy production, serving as a key enabler for the development of efficient, low-carbon processes. As the world shifts its focus to renewable energy sources and sustainable practices, the importance of catalysis becomes increasingly pronounced. Catalysts are substances that accelerate chemical reactions without being consumed in the process, allowing for more efficient transformations of raw materials into valuable products. This efficiency is crucial in minimizing energy consumption and reducing waste, thereby addressing the environmental challenges posed by traditional chemical processes [67].

In the context of solar-driven chemistry, catalysis is essential for harnessing solar energy to drive chemical reactions. Photocatalysts, for instance, utilize sunlight to facilitate reactions that convert CO₂ into useful chemicals or fuels, effectively addressing both energy production and greenhouse gas emissions. The development of advanced photocatalysts that can operate under visible light and exhibit high selectivity is a significant area of research, with the potential to revolutionize how we produce chemicals sustainably. Moreover, catalysis is integral to the concept of circular economy, where the focus is on minimizing waste and maximizing resource efficiency. Catalytic processes can enable the recycling of materials, such as converting waste plastics back into usable chemicals or fuels. This not only reduces the environmental impact of waste but also conserves valuable resources, aligning with the principles of sustainability.

The integration of catalysis into renewable energy systems, such as hydrogen production through water splitting, further exemplifies its impact. Catalysts that facilitate the efficient conversion of solar energy into hydrogen fuel can help decarbonize sectors that are challenging to electrify, such as heavy industry and transportation. This shift not only promotes energy security but also contributes to a significant reduction in carbon emissions [54]. In summary, catalysis is a cornerstone of the new sustainable chemistry landscape. Its ability to enhance reaction efficiency, enable the use of renewable resources, and facilitate waste recycling positions it as a critical technology in the quest for a low-carbon future. As research continues to advance in this field, the potential for catalysis to drive innovation and competitiveness in the chemical industry remains immense, paving the way for a more sustainable and environmentally friendly approach to chemical production.

Molecular catalysis represents a transformative approach in the field of chemistry, offering unique opportunities to enhance reaction efficiency and selectivity at the molecular level. Unlike traditional heterogeneous catalysts, molecular catalysts are defined by their precise structures, allowing for tailored interactions with substrates. This specificity enables the acceleration of chemical reactions while minimizing the formation of unwanted by-products, which is crucial for sustainable industrial processes.

One of the most significant advantages of molecular catalysis is its ability to facilitate complex multistep reactions. By employing well-defined molecular catalysts, chemists can streamline synthetic pathways, reducing the need for multiple reaction steps and thereby improving overall efficiency. This capability is particularly valuable in the production of fine chemicals and pharmaceuticals, where high selectivity and yield are paramount [68].

Recent advancements in molecular catalysis have also opened new avenues for addressing environmental challenges. For instance, the development of catalysts that can efficiently convert CO₂ into valuable chemicals not only helps mitigate greenhouse gas emissions but also contributes to the circular economy by recycling waste into useful products.

Additionally, molecular catalysts can be designed to operate under mild conditions, further reducing energy consumption and enhancing sustainability.

Prominent researchers in this field include Professor Frances H. Arnold, who was awarded the Nobel Prize in Chemistry for her pioneering work on the directed evolution of enzymes, a subset of molecular catalysts [69]. Her research has led to the development of more efficient catalysts that can facilitate complex reactions with high selectivity. Another notable figure is Dr. David W.C. MacMillan, whose work on organocatalysis has transformed the field by demonstrating how small organic molecules can serve as powerful catalysts [70]. His innovations have enabled more sustainable reaction conditions and have applications in pharmaceutical synthesis, where minimizing waste is crucial. Furthermore, Dr. Carolyn R. Bertozzi has made significant contributions by designing molecular catalysts that can selectively functionalize biomolecules [71]. Her research not only advances synthetic chemistry but also has implications for biomedicine, allowing for the development of targeted therapies with improved efficacy. These scientists and their research exemplify the transformative potential of molecular catalysis in both synthetic efficiency and environmental sustainability, illustrating how innovative approaches can lead to practical solutions in addressing global challenges.

Moreover, the integration of molecular catalysis with emerging technologies, such as artificial intelligence and machine learning, is paving the way for the discovery of novel catalysts with unprecedented performance. By leveraging computational methods, researchers can predict catalyst behavior and optimize reaction conditions, accelerating the development of new catalytic systems. Molecular catalysis holds immense potential for revolutionizing chemical processes. Its ability to enhance efficiency, selectivity, and sustainability positions it as a key player in the future of green chemistry. As research continues to evolve, the possibilities for molecular catalysis to drive innovation and address global challenges are boundless, making it an exciting frontier in the quest for sustainable solutions.

New Materials for Energy

The development of new materials is crucial for advancing energy technologies and achieving a sustainable future. As the world increasingly turns to renewable energy sources, the need for innovative materials that can enhance energy conversion, storage, and efficiency becomes paramount. These materials play a vital role in various applications, including solar energy, batteries, fuel cells, and thermoelectric devices [72].

One of the most promising areas of research is in the field of solar energy conversion. Advanced materials, such as perovskite solar cells and quantum-dot solar cells, have shown remarkable efficiency improvements and cost-effectiveness compared to traditional silicon-based solar cells. Additionally, the development of photoelectrochemical cells that utilize novel catalysts can facilitate the conversion of sunlight into chemical fuels, such as hydrogen, thereby providing a clean energy source [73].

In the realm of energy storage, new materials are essential for improving the performance of batteries and supercapacitors. For instance, the exploration of nanostructured materials, such as graphene and transition metal oxides, has led to significant advancements in lithium-ion batteries, enhancing their capacity, charge/discharge rates, and overall lifespan. Furthermore, the development of solid-state batteries, which utilize solid electrolytes instead of liquid ones, promises to increase safety and energy density, making them a viable option for electric vehicles and portable electronics [74].

Fuel cells, which convert chemical energy directly into electricity, also benefit from the innovation of new materials. The design of advanced catalysts, particularly those that can operate efficiently at lower temperatures, is critical for enhancing the performance and

reducing the costs of fuel cells. Research into alternative materials, such as non-precious metal catalysts, aims to make fuel cell technology more accessible and economically viable [75,76].

Thermoelectric materials, which can convert waste heat into electricity, are another area of focus. The development of high-performance thermoelectric materials can improve energy efficiency in various applications, from industrial processes to automotive systems. The exploration and development of new materials for energy applications are vital for addressing the global energy challenge. By enhancing energy conversion, storage, and efficiency, these materials not only contribute to the advancement of renewable energy technologies but also play a crucial role in the transition toward a sustainable, low-carbon future. As research continues to progress, the potential for innovative materials to revolutionize the energy landscape remains significant.

Conclusion

The pursuit of new materials for energy applications is a cornerstone of the transition to a sustainable and low-carbon future. As the world grapples with the challenges of climate change and the depletion of fossil fuels, innovative materials are essential for enhancing the efficiency and effectiveness of renewable energy technologies. From advanced solar cells and high-performance batteries to efficient fuel cells and thermoelectric materials, the development of these new materials holds the promise of transforming how we generate, store, and utilize energy.

The integration of cutting-edge research in materials science with emerging technologies, such as nanotechnology and artificial intelligence, further amplifies the potential for breakthroughs in energy applications. By tailoring materials at the molecular and nanoscale, scientists can create systems that not only improve energy conversion and storage but also reduce environmental impact and promote sustainability. As we move forward, continued investment in research and development, along with collaboration across disciplines, will be crucial in unlocking the full potential of new materials. The innovations that arise from this endeavor will not only drive technological advancements but also contribute to a more sustainable and resilient energy landscape. Ultimately, the future of energy lies in our ability to harness the power of new materials, paving the way for a cleaner, more efficient, and sustainable world.

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The contribution of the authors

Ozan Kartal conducted the entire study independently, including the design, execution, and analysis of the research. His sole effort in this project ensured its successful completion and the development of the manuscript.

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Химия болашағын бағдарлау: тұрақты инновацияның басымдықтары мен мүмкіндіктері (шолу)

Аңдатпа: Бұл шолу мақаласында соңғы бірнеше онжылдықта никель гидроксиді бойынша жүргізілген зерттеулерге шолу жасалады, бұл физикада да, химияда да маңызды инженерлік қолданбалы, әсіресе батареяларда маңызды материал. Ол екі белгілі полиморфтардың, α -Ni(OH)₂ және β -Ni(OH)₂ құрылымдарын сипаттаудан басталады. Мақалада сонымен қатар никель гидроксидінде жиі кездесетін гидратация, қабаттасу ақаулары, механикалық кернеулер және иондық қоспалардың қосылуы сияқты әртүрлі бұзылулар зерттеледі. Байланысты материалдар, соның ішінде интеркалирленген α -туындылары мен негізгі никель тұздары да талқыланады. Шолу никель гидроксидін синтездеудің химиялық және электрохимиялық тұндыру, золь-гель синтезі, химиялық қартаю, гидротермиялық және солвотермиялық синтез, электрохимиялық тотығу, микротолқын көмегімен синтездеу және сонохимиялық әдістер сияқты бірнеше әдістерін жинақтайды. Соңында никель гидроксидінің белгілі физикалық қасиеттері — магниттік, дірілдік, оптикалық, электрлік және механикалық

— зерттеледі. Қорытынды бөлім осы материалдардың әлеуетті құнды қасиеттерінің қысқаша мазмұнын және никель гидроксиді негізіндегі белгісіз үлгілерді анықтау және сипаттау әдістерін ұсынады.

Түйін сөздер: Тұрақтылық, Биоөңдеу зауыты, Күн энергиясын түрлендіру, Энергияны сақтау, Көмірқышқыл газын пайдалану, Катализ, Циркулярлық экономика, Жаңартылатын ресурстар.

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Навигация в будущее химии: приоритеты и возможности для устойчивых инноваций (обзор)

Аннотация: В эссе исследуется меняющийся ландшафт энергетического и химического производства, с упором на растущее внимание к устойчивости за последнее десятилетие. В нем освещаются ключевые области исследований, которые привлекли значительное внимание, такие как биопереработка, преобразование солнечной энергии, материалы для хранения энергии и использование углекислого газа. Авторы подчеркивают необходимость инновационных решений в катализе, проектировании процессов и использовании альтернативного сырья и источников энергии. Они выступают за более комплексный взгляд на устойчивость, учитывая как экономические, так и социально-экологические факторы, и поощряют дальновидный подход к решению будущих тенденций и проблем. Цель этого анализа — мотивировать исследователей и участников отрасли на изучение новых технологий и методов, которые приведут к

более устойчивому будущему в области химии и энергетики.

Ключевые слова: Устойчивое развитие, Биопереработка, Преобразование солнечной энергии, Хранение энергии, Утилизация углекислого газа, Катализ, Круговая экономика, Возобновляемые ресурсы.

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Physical geographical basis for the formation of the names of mountain glaciers in Uzbekistan and the problem of transcription of glacionyms (using the example of glacionyms of the Piskom basin)

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Abstract. This article focuses on the subject of mountain glaciers in Uzbekistan, including their geographical position, the origin of glacionyms (geographical names of glaciers), their interpretations, and their interrelation with physiographic factors and natural conditions. The analysis is based on the Piskom basin and adjacent areas. In the toponymy of the Piskom basin, physical geographical terms such as “tor”, “say (suv, bulak)”, “ashuv”, “tash”, “bel” and their areas have been determined, and the share of these terms in the formation of toponyms has been determined. Based on the fact that more than 65% of the toponyms of the basin were formed at the expense of the above physical geographical terms, the physical geographical basis of the toponymy of the area has been scientifically proven. Various sources have provided suggestions and recommendations on the writing of Piskom basin glacionyms and their correct use in practice.

Key words: geographical names (toponyms), glacionyms, phytoglacionyms, zooglacionyms, geographical atlases, cartographic sources, transcription.

Introduction

Mountain glaciers are important in providing drinking water to mankind. Global climate change is causing a rapid reduction in the area of mountain glaciers on the Earth's surface. This situation leads to a sharp decrease in the area of glaciers, especially in the arid climate regions of Central Asia, including Uzbekistan. At the same time, the number of small glaciers is increasing due to the fact that several large glaciers in the mountains of our planet are breaking up into smaller parts as their area decreases. All these processes are being studied in depth by our glaciologists. However, it can be seen that the scientific sources they rely on are mostly written in Russian, where a number of glacier names have been changed to varying degrees, sometimes written in a very wrong context. This causes a number of inconveniences for researchers when working with existing scientific and cartographic sources.

The purpose of this scientific article is to determine the features of the formation of the names of mountain glaciers on the example of glacionyms of the Piskom river basin, to interpret some glacionyms from a scientific point of view, and to make suggestions on their correct writing in cartographic sources. To achieve this goal, the following tasks have been set:

1) to determine the geographical location of the mountain glaciers of the Piskom basin and the physical geographical basis of their naming;

2) to interpret glacionyms from a scientific point of view and to develop recommendations on the correct spelling of glacier names in various cartographic sources in Uzbek.

Methods and materials

According to data, the number of mountain glaciers in Uzbekistan is 353, and their total area is 200.1 sq. km [7; p. 34]. Most of them are located in the Western Tien Shan, Hisar and adjacent ranges and are unevenly distributed.

In the Piskom river basin, the area is 102.52 square meters. The existence of 262 large and small glaciers with km was recorded (Table 1) [9].

Table 1. Information on the area and number of glaciers in the Piskom river basin

Small river basins	The number of glaciers	Total area of glaciers, sq. km
Moshtasgansay	1	0.06
Ispaysay	10	0.77
Kaphtarkumushsay	3	0.38
Kogarikapchigaisay	1	0.10
Bodakhsay	2	0.22
Ikhnachsay	3	0.37
The headwaters of the Piskom River	4	0.54
Chorolma	4	0.57
Beshtor	15	3.58

Physical geographical basis for the formation of the names of mountain glaciers in Uzbekistan and the problem of transcription of glacionyms (using the example of glacionyms of the Piskom basin)

Kuksuv	25	6.27
Barkiraksay	9	5.18
The beginning (left) part of the Aygaing river	3	1.83
Akkopchigaysay	19	7.25
Tastorsay	9	4.05
Shavursay	28	18.99
Tekisashuv	2	0.74
Karakush	2	0.27
Saribashsay	1	0.32
The beginning (right) part of the Aygaing River	3	0.45
Atmitash	3	0.21
Ayutor of the Aygaing	7	2.86
Tekeshsay	6	2.62
Torakain	4	1.54
Atyaylau	3	0.25
Kukargentau	7	3.07
Kukbulak	2	0.27
Akbulakulken	2	2.10
Karabulak	2	0.99
Chotan	15	10.87
Ashutar	7	2.75
Kurumtar	10	2.16
Ayutor of the Maydantal	12	10.53
Maydantal	1	0.19
Tuprakbel	6	1.45
Kukhnazarsay	7	1.88
Karabaur	1	0.10
Anaulgensay	14	4.91
Karakizsay	9	1.83
Total by basin	262	102.52

The table was compiled by the authors based on the data of A.S.Shetinnokov and L.D.Podkopaeva (1968).

The discussion of the results

The glacionyms of the Piskom river basin contain a large proportion of phytoglacionyms and zooglacionyms. The terminological structure of basin glacionyms is also unique. Toponyms of

the Piskom basin, including glacionyms, often contain physical geographical terms such as “*tash*”, “*tor*”, “*bel*”, “*oshuv*”, “*say (suv, bulak)*” (Fig. 2). This is directly related to the natural conditions of the area, mainly the relief structure and hydrographic features.

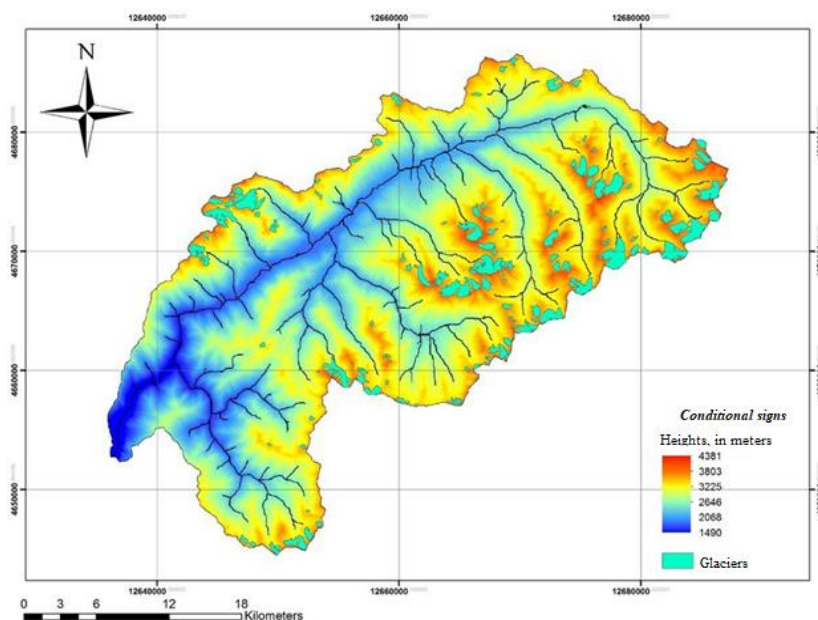


Figure 1. Map of the geographical location of mountain glaciers in the upper part of the Piskom basin

The term “*tor*” that formed basin glacionyms is specific for this region - the Piskom basin, and it almost does not participate in the formation of toponyms in other regions of Uzbekistan. The word *Tor* means the narrowest part of a mountain valley. In the Kazakh and Kyrgyz languages, the word “*tor*” means mountain pasture. In the old Turkish language, the word “*tor (ter)*” means “*special passage*”, “*opposite passage*” (in the sense of a two-way road – M.A.).

In the Kazakh language, the term “*ter*” means “*the highest part of the mountain valley*”. Usually, beyond the so-called narrow part of the mountain, the pass begins [1]. In Kyrgyz language, “*tor*” means “*special place, high mountain pasture*”.

In terms of geographical content, the word “*tor*” has several other meanings besides the above: a concave relief form formed by glaciers in the mountains – glacial cirque, kar, mountain gorge (*tangi*), a convenient place for a pass, a passage to the other side of the mountain, etc.

So, *Ayutor*, *Beshtor*, *Jamaltor* (probably *Yomontor* – M.A.), *Chakirtor*, *Tuyuktor*, *Kyziltor*, *Karaboshtor*, *Kuyumtor*, *Ashutor* (probably *Oshuvtor* – M.A.), *Kukargantor* located along the watershed of the basin dozens of glaciers and several other geographical features are not named so for nothing. Such toponyms indicate the natural conditions of the region, especially the geological-geomorphological structure. At the same time, geographical names with a “*tor*” component form a separate area in this basin and become “*endemic*” for the toponymy of the basin.

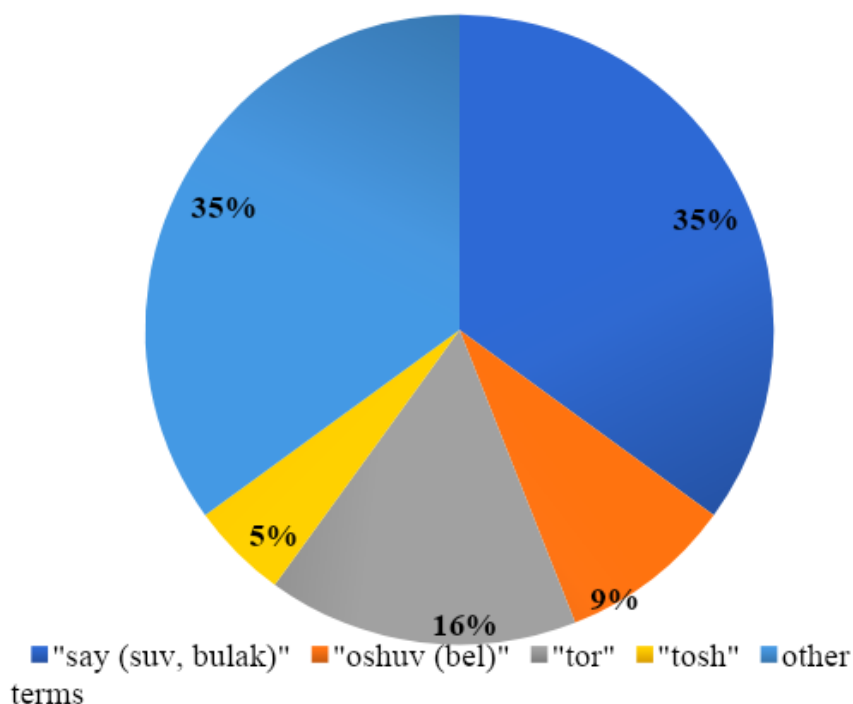


Figure 2. The share of physical geographical terms in the names that formed glacionyms of the Piskom river basin, in %

Among the glacionyms of the Piskom basin, the names formed on the basis of the topoterms "*bel*" and "*oshuv (overhead)*" are often found. In "Boburnoma" there is information that the terms "*dovan*", "*kotal*", "*dobon*" and "*band*" synonymous with these terms are used [3; p. 22]. The main reason for this is the geomorphological structure of the area. It is known that glaciers can be formed due to the accumulation of snow cover in the low, smooth terrains that can be crossed at the junction of two mountain ranges. Conditions for the formation of glaciers can be created especially in peaks with a high absolute height. Since most of the mountains surrounding the Piskom river valley are higher than 3000-3500 meters, it is natural that the terms "*bel*" and "*oshuv*" were involved in the naming of glaciers formed in such peaks.

The geomorphological structure is complex, the lithological composition of the rocks is strong and diverse, there are favorable natural conditions for precipitation and flow formation in areas with a large difference in elevation and slope of the earth's surface, as well as on the slopes facing moist air masses. This serves for the formation of permanent and temporary running water. For this reason, the density of the hydrographic network is much greater in mountainous areas than in plains.

The Piskom basin is also rich in streams and rivers, in accordance with its name (here: *Piskom in Persian-Tajik (bist+kom) – "twenty waters" – "streams are many places" – M.A.*). Most of the streams that supply them with water are fed by mountain glaciers. That is, most streams and rivers in the basin are rivers that are saturated with ice-snow waters according to the type of saturation. Therefore, in the names of the glaciers that supply water to these streams and rivers,

folk terms related to hydrology such as “say”, “suv”, “bulak” (most of them are secondary names, originally they were the names of streams and brooks originating from these glaciers, later they were transferred to the name of glaciers – M.A.) attended [4].

The term “**say**” is used in the form of “chay (choi, choy)” in Turkey and Azerbaijan. In Western Turkmenistan, this term is used in the form of “soy” and means “dry stream”, “flat ravine”, “hollow”, “small river”. Regarding the meaning of this term, the opinions of S.Karaev and M.Mirakmalov complement each other. According to them, the term “sai” means “small river”, “flowing water”, “waterway”, “valley”, “lowland with flowing water” and forms place names in several regions of our country [2; pp. 52-53, 3; p. 169, 8; p. 93].

According to S.Karaev, in some regions of Uzbekistan, a channel opened using old channels is also called a stream. The famous toponymist and terminologist E.Murzaev says that “soy (say, sayr, chay)” is a Turkish word that means “mountain stream (small mountain river)”, “valley” [5; p. 195]. According to the information of the famous toponymist, 406 place names made using stream toponym are stored in the toponyms card of the Tomsk Pedagogical Institute. T.Nafasov, a mature specialist in the toponymy of the Kashkadarya region, defines the word (term) “say” as follows: “say is a lake surrounded by ridges on both sides and a valley in the middle. A stream is a small flowing water in which rainwater flows in the spring and dries up in the summer” [6]. The term “suv” is also commonly used synonymously with “say”, that is, in the sense of “flow of water”.

In geographic literature and cartographic sources, confusions and incorrect translations often occur when writing different toponyms. In general, a number of works have been carried out regarding the writing, transcription and transliteration of toponyms located in the regions bordering Uzbekistan in Uzbek. Nevertheless, incorrect use (writing and pronunciation) of place names, especially glazionyms, is still found in various geographical and non-geographical literature, maps and atlases, dissertations and other sources.

For example, in some Uzbek-language sources, the name of Ikhnoch lake (stream and glacier) is often mistakenly used in forms such as Ikhnoch, Titov glacier as Titova, and Barkirak glacier and stream as Barkrak. In order to avoid such confusions and to fix glazionyms in Uzbek sources in a form that is compatible with language rules and easy to pronounce, we have combined our thoughts on the etymology of the name of the Piskom basin glazionyms in the Uzbek alphabet based on the Latin script and the etymology of the place name. It is presented in Table 2 below.

Table 2. Information about the names of some glaciers in the mountains located in the Piskom basin and adjacent areas and their meaning

№	Glasionim's writing on the studied topomap	Small river basin	The writing of Glasionim in Uzbek language (Latin script)	The meaning of the toponym
1	Маштасгон	Piskom	Moshtasgon	<i>An area with many small boulders</i>
2	Испасай	Piskom	Ispaysoy	<i>The etymology is unknown, an obscure name</i>
3	Каптаркумыш	Piskom	Kaptarkumush	<i>A place where there are many silver doves</i>

Physical geographical basis for the formation of the names of mountain glaciers in Uzbekistan and the problem of transcription of glacionyms (using the example of glacionyms of the Piskom basin)

4	Когарыкапчигасай	Piskom	Kogariqopchig'aysoy	<i>A stream flowing through a long, narrow and steep gorge</i>
5	Бодаксай	Piskom	Bodaksoy	<i>Botoq is a stream flowing from a depression at the foot of a mountain</i>
6	Ихначсай	Piskom	Ixnachsoy	<i>A stream flowing from an area where the ixnach plant grows abundantly</i>
7	Чаралма	Chorolma	Chorolma	<i>An area with four sides of apple trees</i>
8	Бештор	Aygaing	Beshtor	<i>The place where there are five passes</i>
9	Джамалтор	Aygaing	Jamaltor	<i>The junction of the passes</i>
10	Туюктор	Aygaing	Tuyuqtor	<i>A pass located in a closed area with no exit</i>
11	Чакыртор	Aygaing	Chaqirtor	<i>A pass with a lot of jagged rocks</i>
12	Джаяктор	Aygaing	Jo'yaktor	<i>A narrow pass</i>
13	Чукуртор	Aygaing	Chuqurtor	<i>A pass located in a steeply low area from the surroundings</i>
14	Кызылтор	Aygaing	Qiziltor	<i>Pass where red (magmatic) rocks are scattered</i>
15	Терметаш	Aygaing	Termetash	<i>Terme (terme) – avalanche / sorted rock / separate mountain peak</i>
16	Караканыш	Aygaing	Qoraqanish	<i>Khan's wife, princess</i>
17	Тундуксай	Aygaing	Tunduksoy	<i>A stream flowing from the northern slope of the mountain</i>
18	Исеноман	Aygaing	Esonomon	<i>A sputtering, dangerous waterway</i>
19	Аксаксой	Aygaing	Oqsoqsoy	<i>Flowing water that often turns and changes its direction</i>
20	Карабастор	Aygaing	Qoraboshtor	<i>A pass with exposed rocks (or a pass with a lot of vegetation of the same name)</i>
21	Баркрак	Aygaing	Barqiroq	<i>A noisy creek</i>
22	Тюякарын	Aygaing	Tuyaqorin	<i>A height similar to a camel's belly, uneven terrain</i>
23	Аккапчигай	Aygaing	Oqqopchig'ay	<i>A narrow gorge where the snow does not melt in the upper part</i>
24	Тастарсай	Aygaing	Tastorsoy	<i>A stream starting from a rocky pass</i>

25	Текетур	Aygaing	Teketur	<i>Pass near the peak (tege – mountain peak, tor – pass)</i>
26	Титова	Aygaing	Titov	<i>Related to the name of the cosmonaut German Titov</i>
27	Гагарина	Aygaing	Gagarin	<i>Cosmonaut Yuri Gagarin is associated with the name</i>
28	Пахтакор	Aygaing	Paxtakor	<i>Related to the cotton plant and its picking</i>
29	Токмасалды	Aygaing	To'qmasoldi	<i>The etymology is unknown, an obscure name</i>
30	Имени Географака САГУ	Aygaing	O'zMU geografiya fakulteti nomidagi	<i>It is related to the name of the first geography faculty established in Uzbekistan</i>
31	Калесника	Aygaing	Kalesnik	<i>It is associated with the name of the famous geographer, limnologist, academician S.V.Kolesnik</i>
32	Козий	Aygaing	Koziy	<i>Related to the name of a person (anthroponym)</i>
33	Тюзашу	Aygaing	Tekisoshuv	<i>A slightly inclined and straight pass</i>
34	Карагуш	Aygaing	Qoraqush	<i>Associated with the name of the bird / rocky land where no plants grow</i>
35	Сарыбаш	Aygaing	Saribosh	<i>A place without vegetation at high altitude</i>
36	Атмыташ	Aygaing	Atmitosh	<i>there are many places with jagged stones</i>
37	Аютор	Aygaing	Ayutor	<i>A pass where there are many bears</i>
38	Текешсай	Aygaing	Tekeshsoy	<i>A stream flowing from the area where the tekesh/tyanish plant (deer grass) grows</i>
39	Турагаин	Aygaing	To'raqayin (Turoqqayin)	<i>Big Birch (area where birch grows a lot)</i>
40	Атжайлау	Maydantal	Otyaylov	<i>A lawn where horses graze</i>
41	Когургентор	Maydantal	Ko'kargantor	<i>A green, grassy pass</i>
42	Кокбулак	Maydantal	Ko'kbuloq	<i>A spring in a place where green plants grow a lot (a spring with clear water)</i>
43	Акбулакулькен	Maydantal	Oqbuloqulkan	<i>A large spring fed by snow</i>
44	Карабулак	Maydantal	Qorabuloq	<i>A spring that feeds from the ground water</i>

45	Чотан	Maydantal	Chotan	<i>The etymology is unknown, an obscure name</i>
46	Торашу	Maydantal	To'roshuv	<i>The place where the passes cross</i>
47	Корумтор	Maydantal	Qurumtor	<i>Pass consisting of a pile of stones</i>
48	Ашутор	Maydantal	Oshuvtor	<i>A pass, a place to go over a mountain</i>
49	Койназар	Maydantal	Ko'ynazar	<i>A very narrow and deep gorge</i>
50	Карабау	Maydantal	Qorabaur	<i>The etymology is unknown, an obscure name</i>
51	Анаульген	Maydantal	Anaulkan	<i>Big creek, main stream</i>
52	Каракыз	Maydantal	Qoraqiz	<i>A stream flowing through a narrow gorge</i>

The table was compiled by the author, and the names in the 1st column of the table are given in Russian, as the topographic map on which glacionyms were studied is in Russian.

It should be emphasized that it is difficult to give a definite opinion about the etymology of toponyms, and we are far from it. Usually, etymologically based variants are provided by experts, and some of these variants are widely used by "consumers". In the course of research, it was not possible to determine the etymology of several glacier names, and it can be seen from this that this issue requires separate monographic studies, toponymic research and expeditions.

We think that our small work on the correct spelling and pronunciation of glacionyms in Uzbek can be useful for experts directly dealing with glaciers, as well as for other fields, including mass and print media workers, pedagogues.

Conclusions

Piskom river basin is distinguished by the nature and uniqueness of toponyms. This can also be seen in the case of glacionyms in the Piskom Basin and adjacent areas. Geographical place names formed on the basis of a narrow toponym in basin toponymy form an area, and this situation is characteristic only for this area – "endemic". In the formation of toponyms of the basin, this term takes part mainly in the meaning of a pass or a pass, and in some cases in the meaning of the highest part of the mountain. The toponymy of the Piskom Basin is complex, with terms related to the Uzbek, Kyrgyz, Kazakh, and Tajik languages and their various dialects being widely used. Therefore, it is necessary to study the toponymy of this area in a separate monographic way and to create an explanatory dictionary of toponyms of the area, to achieve the correct spelling of basin toponyms, including glaciation names, in cartographic and other geographical sources in Uzbek, and to consolidate and standardize them by entering them into the state register.

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Өзбекстандағы тау мұздықтары атауларының қалыптасуының табиғи географиялық негіздері және гляционимдер транскрипциясы мәселелері (Пскем алабының гляционимдери мысалы)

Аңдатпа. Мақалада Өзбекстанның таулы мұздықтары, олардың географиялық орны, мұздық атауларының шығу тегі – гляционимдер, олардың түсіндірмесі, сондай-ақ Пскем алабының және оған іргелес жатқан аумақтар мысалында олардың табиғи географиялық факторлармен және табиғи жағдайлармен байланысы туралы сұрақтар қарастырылды. Алаб топонимдерінің жасалуындағы «тар», «сай», «ошув», «тош», «бел» табиғи географиялық терминдерінің үлесі анықталып, таралу ареалдары айқындалды. Өзен алабы топонимдерінің 65%-дан астамы жоғарыда келтірілген табиғи географиялық терминдер арқылы жасалған, осының негізінде

бұл алап топонимдерінің табиғи географиялық негіздері ғылыми түрде дәлелденген. Пскем алабындағы мұздық атауларының дұрыс жазылуы және практикада қолданылуы бойынша ұсыныстар берілген.

Түйін сөздер: географиялық жер-су атаулары (топонимдер), топонимдерның түрлері, гляционимдер, фитогляционимдер, зоогляционимдер, географиялық атластар, картографиялық дереккөздер, транскрипция.

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Физико-географические основы формирования названий горных ледников Узбекистана и проблемы транскрипции гляционимов (на примере гляционимов бассейна Пскем)

Аннотация. В данной статье рассматриваются вопросы о горных ледниках Узбекистана, их географическое положение, о происхождении гляционимов – географических названиях ледников, их толкований, а также их взаимосвязь с физико-географическим факторами и природными условиями на примере Пскемского бассейна и прилегающих территорий. Определена доля физико-географических терминов «тор», «сай», «ошув», «тош», «бел» в формировании топонимов региона, а также определены ареалы их распространения. Более 65% топонимов бассейна образованы при помощи вышеперечисленных физико-географических терминов, на основе этого научно доказаны физико-географические основы топонимов данного бассейна. Даны предложения и рекомендации по правильному написанию и их использованию на практике гляционимов бассейна Пскем.

Ключевые слова: географическое название (топонимы), типы топонимов, гляционимы, фитогляционимы, зоогляционимы, географические атласы, картографические источники, транскрипция.

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Научная статья

Экологические происшествия при управлении отходами горнодобывающей промышленности

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Аннотация. В работе проведено геоэкологическое исследование территории карьера Шаймерден и бывшего озера Сорколь. Рекомендована наилучшая доступная технология для предотвращения возникновения экологических происшествий при добыче руды. Научная новизна исследования заключается в описании явления исчезновения водного объекта в результате техногенной деятельности при добыче свинцово-цинковой руды. Образцы проб почвы с бывших донных отложений были исследованы на химический анализ. В целом характер показателей почвы указывает на то, что грунт уже в течение нескольких лет не покрыт водой. Биоиндикационный и маршрутный методы были использованы для подтверждения смены водной экосистемы на луговую. В качестве признаков были зафиксированы представители животного мира, такие, как лисы и зайцы, а абсолютным доминантам среди видов растительности является Кохия веничная. С помощью картографических методов была визуальна запечатлена динамика исчезновения водоема. Результаты позволили сделать предположение о том, что высыхание водного объекта связано с деятельностью карьера Шаймерден.

Ключевые слова: Экологический Кодекс, геологоразведочные работы, единая информационная система охраны окружающей среды, наилучшая доступная технология, отходы горнодобывающей промышленности, крупное экологическое происшествие, разведка месторождений полезных ископаемых.

Введение

Актуальность исследования в том, что горнодобывающая промышленность является одним из наиболее значимых секторов экономики Казахстана. Многочисленные предприятия вовлечены в непосредственную разведку и добычу, а также обеспечивают логистические операции по использованию недр, что обусловлено большим разнообразием извлекаемых ресурсов. Помимо сырья, необходимого для производства и потребления, в промышленности образуется целый ряд отходов, включая шлам, хвосты флотации, вскрышные породы при открытой разработке месторождений, вмещающие породы при добыче полезных ископаемых и многое другое. Опасные и неопасные отходы от добычи и переработки полезных ископаемых разделяются в соответствии со статьей 338 Экологического кодекса Республики Казахстан [1]. В 2022 году горнодобывающий сектор страны произвел 712,2 млн т отходов, что на 242,3 млн т больше, чем в 2021 году. За это же время горнодобывающие компании произвели 31,8 млн т опасных отходов, что на 24,7% больше, чем в 2021 году [2]. Производство опасных и неопасных отходов в основном связано с предприятиями горнодобывающей промышленности.

Согласно «Национальному докладу о состоянии окружающей среды и об использовании природных ресурсов Республики Казахстан за 2022 год», объем неопасных отходов в Казахстане увеличился на 51,5% по сравнению с 2021 годом. Это недвусмысленно демонстрирует, как развивалась отрасль и как увеличивались объемы отходов, что усиливало воздействие на окружающую среду [3].

Высшее руководство страны подтвердило актуальность проблемы. Президент Республики Казахстан утвердил концепцию перехода страны к «зеленой экономике» в Указе № 577 от 30 мая 2013 года. Эта стратегия определяет действия по осуществлению перехода к «зеленой экономике», которая охватывает следующие области: устойчивое использование водных ресурсов, развитие системы управления отходами, снижение загрязнения воздуха, а также защита экосистем и управление ими [4]. В дополнение к национальным программам Казахстан подписал ряд международных природоохранных соглашений, в том числе регулирующих обращение с отходами. 10 февраля 2003 года правительство приняло закон № 389, который позволил стране присоединиться к Базельской конвенции о контроле за трансграничной перевозкой опасных отходов и их удалением. В результате были установлены требования, включая обеспечение того, чтобы производство опасных и других отходов было сведено к минимуму с учетом социальных, технологических и экономических соображений [5]. Последние события свидетельствуют о том, что правительство страны осознает необходимость надлежащего обращения с отходами для обеспечения долгосрочного развития и охраны окружающей среды.

Методология

Озеро Сорколь расположено между карьером АО «Шаймерден» и Красногорским рудником в Камышинском районе Костанайской области, в 60 км к юго-западу от Лисаковска и в 156 км к юго-западу от Костаная (рис. 1). АО «Шаймерден» является

дочерним предприятием ТОО «Казцинк». Месторождение окисленных свинцово-цинковых руд, открытое в 1992 году, является уникальным по содержанию цинка (в среднем более 20%), не имеющим аналогов в Казахстане и странах СНГ. Месторождение разрабатывалось открытым способом, на территории исследования находятся карьер и отвалы. Рельеф местности равнинный, абсолютные высоты колеблются от 240 до 247,5 м. Ландшафт, окружающий свалку, сложен озерными впадинами и необычной сетью оврагов и балок [7, с. 9].



Рисунок 1. Спутниковый снимок местоположения озера Сорколь

Шахтные воды собирались и транспортировались с помощью системы водозабора Шалманского пруда, расположенного недалеко от озера. В течение многих десятилетий шахтные воды из карьеров № 3 и 1 Красногорского рудника КБРУ (АО «Алюминий Казахстан») сбрасывались в озеро Сорколь. Нараннихэтапахисследованияместорождения Шаймерден исследователи проанализировали потенциальные угрозы, связанные с этим водоемом. Они расценили это как серьезную опасность, поскольку это могло привести к серьезному загрязнению горных выработок, в частности, месторождения Шаймерден. Эта оценка послужила основой для принятия решения о сбросе карьерных вод из этого места в бассейн озера Кояндыкопа [7, с. 11].

До 2008 года план осушения карьеров Красногорского рудника предусматривал открытую дренажную систему со сложными отстойниками и водопонижающими колодцами, подключенными к общей напорной трубе, проложенной к озеру Сорколь. Последний был построен на фундаменте одноименного природного озера, которое, помимо шахтных вод, питается за счет паводкового стока с юга по Шалманскому оврагу и может пропускать до 3,5 млн м³ внешней воды в многоводный год. Весеннее половодье 1994 года привело к переполнению озера Сорколь и затоплению лесополосы на северном берегу водохранилища, что потребовало немедленного строительства заградительных дамб [8, с. 2].

Разработка карьера на месторождении была завершена в 2011 году. Оставшиеся добытые необработанные залежи концентрируются в рудоотвалах, где руда измельчается и направляется на дальнейшую переработку. Валуны вскрышных пород, извлеченные из недр при разработке запасов, складываются в отвал породы на поверхности. На начало 2023 года остатки товарной руды на отвалах карьера Шаймерден составляют 932,6 млн т [7, с. 12].

Сотрудники «Неправительственного экологического фонда имени В.И. Вернадского в Республике Казахстан» опросили местных жителей, которые заявили, что водоем еще существовал в период с 2000 по 2005 год, наполняясь в периоды половодья [9, с. 17]. Спутниковое изображение района исследования за 2014 год наглядно показывает наличие воды в озере, однако размер самого водоема значительно меньше по сравнению с предыдущими периодами (рис. 2).



Рисунок 2. Спутниковый снимок района исследования в апреле 2014 года

К 2015 году озеро Сорколь полностью высохло, о чем свидетельствуют последние спутниковые снимки. На следующем спутниковом снимке, сделанном в апреле 2022 года (во время весеннего половодья), озеро как таковое не изображено, и несколько автомобильных дорог пересекают высохшее дно во всех направлениях (рис. 3).



Рисунок 3. Спутниковый снимок района исследования в апреле 2022 года

Чтобы исследовать процессы исчезновения озера Сорколь, с 2004 по 2020 год с помощью программного обеспечения Google Earth Pro были изучены спутниковые изображения [10]. Местоположение района проведения исследований было определено путем объединения описания объекта исследования с географическими координатами самого озера. Затем были выделены контуры озера: во время паводка, промышленные зоны АО «Шаймерден» и Красногорского бокситового рудника АО «Алюминий Казахстан», а также отвалы горной породы. Инструмент «Добавить полигон» позволял очертить контуры объектов и подписать их. При построении контура озера Сорколь в качестве основы был использован спутниковый снимок исследуемого участка, сделанный в 1985 году, поскольку выбранный масштаб включает только моментальный снимок местности во время паводка. Чтобы очертить контуры фирм, был использован самый последний снимок - в данном случае спутниковый снимок 2022 года, который охватывал всю территорию промышленных объектов.

Чтобы оценить динамику развития исследовательского объекта с 2004 по 2020 год, важно удалиться от поверхности земли, поскольку имеется больше спутниковых фотографий объекта в меньшем масштабе. Затем с помощью функции «Показать исторические фотографии» были получены изображения предшествующих лет. Для сохранения полученных данных был использован инструмент «Сохранить изображение». Для получения высококачественных фотографий были внесены некоторые изменения:

Компас был направлен точно на север;

Масштаб был определен в 7 км;

Названия на карте и условные обозначения были стерты, так как в этом не было необходимости.

Таким образом, было собрано 17 изображений места исследования. Затем фотографии были объединены в фильм, что позволило нам увидеть не только динамику исчезновения озера, но и антропогенную модификацию окружающей местности (рис. 4). Кроме того, был сгенерирован индекс NDWI, чтобы математически подтвердить, что водоем высох.



Рисунок 4. Спутниковый снимок района исследования за 2010 год

В этом исследовании использовался нормализованный индекс разности водоемов (NDWI), который широко используется для измерения содержания воды в растениях и обнаружения водных объектов на поверхности земли. Эффективность NDWI особенно высока в районах с высокими сельскохозяйственными показателями и для мониторинга изменений в водных ресурсах.

Формула для расчета индекса NDWI следующая:

$$NDWI = \frac{(GREEN - NIR)}{(GREEN + NIR)} \quad (1)$$

где: GREEN – отражение в зеленом канале;

NIR – отражение в ближнем инфракрасном канале.

Для получения необходимых данных были использованы спутниковые снимки Landsat 7 и Landsat 8, доступные через платформу EarthExplorer. Спутник Landsat 7 содержит спектральный канал GREEN как часть канала 2 (0,52–0,60 мкм), а канал NIR представлен в канале 4 (0,77–0,90 мкм). Для Landsat 8 эти данные соответствуют каналу 3 (0,53–0,59 мкм) для GREEN и каналу 5 (0,85–0,88 мкм) для NIR [11].

После скачивания изображений с использованием EarthExplorer расчет NDWI производился в программном обеспечении ArcGIS через инструмент Raster Calculator, который позволяет выполнить необходимые арифметические операции с растровыми картами. Процесс расчета включал загрузку соответствующих каналов, выполнение расчета по указанной формуле и сохранение полученных данных в виде нового растрового слоя (рис. 5).

Для графического представления и дальнейшего анализа результатов использовалась программа QGIS. Этот инструмент обеспечивал возможности для визуализации, создания картографических композиций и анализа пространственных данных, что было ключевым для интерпретации изменений в распределении водных ресурсов.

Данный метод позволяет наглядно оценить распределение водных ресурсов на исследуемой территории, а также отслеживать динамику изменений за интересующий период.

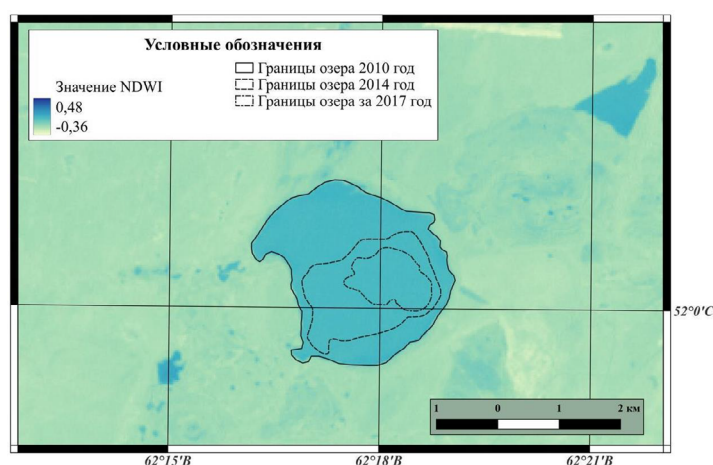


Рисунок 5. Значение индекса NDWI для озера Сорколь в 2010 году

Результаты и Обсуждение

Динамика исчезновения озера Сорколь с 2004 по 2020 год показывает, что водоем начал быстро высыхать в 2011 году и полностью обмелел к 2015 году. С 2016 по 2020 год озеро было заполнено, хотя его объем не увеличился до уровня 2011 года. Обобщенные карты, основанные на индексе NDWI, дают те же результаты. В то же время, начиная с 2011 года, фотографии и карты показывают наличие нового водоема к юго-западу от дна озера. Этот объект растет в размерах и не исчезнет до 2020 года. На спутниковом снимке 2022 года также видно водохранилище рядом с местом проведения исследований. Объект появился в карьере месторождения Шаймерден после прекращения деятельности предприятия в 2011 году. В последующие годы разработка месторождения не велась, но вскрышные породы из отвалов перерабатывались для получения свинцового концентрата. Более того, записи показывают, что до закрытия предприятия минерализация воды в шахте соответствовала показателям воды из озера Сорколь. В ходе полевых исследований специалисты встретились с сотрудниками АО «Шаймерден», которые заявили, что озеро питается из подземных источников. Подземные воды впадали в карьер, наполняя и, возможно, по сей день питают его.

Озеро Сорколь было утеряно в результате остановки добычи на месторождении Шаймерден. После завершения работ карьер должен был быть засыпан вскрышными породами, чтобы предотвратить попадание грунтовых вод в шахту, как того требует Экологический кодекс Республики Казахстан.

В целом, почвы имеют нейтральную среду. Почвы чрезвычайно засолены; тип засоления 0 содовое, о чем свидетельствует высокое содержание густого осадка и удельная электрическая проводимость, составляющая 1980 мСм/см. Почва содержит минимальное количество гумуса, но при этом богата питательными веществами, которые легко доступны. Ее можно использовать в качестве почвенной добавки или удобрения. Однако карбонаты и бикарбонаты наиболее ядовиты для растений. Гранулометрический состав, по Качинскому, представляет собой легкий суглинок. В целом, характер почвенных показателей свидетельствует о том, что почва не насыщалась водой в течение нескольких лет. Результаты испытаний в соответствии с протоколом № 74Р приведены в таблице 1.

Таблица 1. Основные показатели почв бывших донных отложений [9]

№	Наименование показателей	Фактические результаты	Превышение ПДК
1	Нитритный азот, мг/кг	66,10	Высокое
2	Подвижный фосфор, мг/кг	43,96	Повышенное
3	Подвижный калий, мг/кг	493	Очень высокое
4	Подвижная сера, мг/кг	135,79	Очень высокое

5	Гумус, %	2,00	Низкое
6	pH (KCl)	7,23	Нейтральное
7	*pH	7,58	Нейтральное
8	Кальций в водной вытяжке мг-экв/100 г	11,75 (0,235%)	-
9	Магний в водной вытяжке, мг-экв/100 г	2,00 (0,0244%)	-
10	Натрий, мг-экв/100г	7,62 (1,75%)	-
11	Хлориды ммоль/100 г	2,2 (0,0781%)	-
12	Сульфаты, ммоль/100 г	4,1 (0,197%)	-
13	Удельная электрическая проводимость, мСм/см	1980	-
14	Карбонаты в водной вытяжке, мг-экв/100 г	Не обнаружено	-
15	Гидрокарбонаты в водной вытяжке, мг-экв/100 г	166,9 (10,2%)	-
16	Плотный остаток водной вытяжки	1,212%	-
17	Органический углерод почвы	1,16%	-
18	Гранулометрический состав почвы	Потеря при обработке -13,584%, 1-0,25 мм - 59,95%, 0,25-0,05 мм - 9,745%, 0,05-0,01 мм - 1,308%, 0,01-0,005 мм - 0,388%, 0,005-0,01 мм -2,472%, <0,001 мм - 26,136% Песок - 71,005%, Глина - 2,859%, Ил - 26,136%	

Примечание: Составлено на основе данных из [9].

Было изучено содержание в почве следующих компонентов: нитритный азот, фосфор, калий, сера, гумус, pH (KCl), pH кальция, магния, натрия, хлоридов, сульфатов, удельная электропроводность, карбонаты, бикарбонаты, плотный остаток, органический углерод, гранулометрический состав почвы.

Согласно результатам анализа, показатели в норме, за исключением нескольких компонентов: нитритный азот – 66,10 высокий избыток, фосфор – 43,96 повышенный, калий – 493 чрезвычайно высокий, сера – 135,79 чрезвычайно высокий, гумус – 2,00 низкий.

Другие компоненты, изученные в осадках, находятся в норме: pH (KCl) – 7,23 нейтральный, pH – 7,58 нейтральный, кальций – 11,75, магний – 2,00, натрий – 7,62,

хлориды – 2,2, сульфаты – 4,1, электропроводность – 1980, карбонаты – не обнаружены, бикарбонаты – 166,9, плотный остаток – 1,212%, органический углерод – 1,16%.

По гранулометрическому составу почва составляет: песок – 71,005%, глина – 2,859%, ил – 26,136%. Образцы почв со дна озера указывают на наличие солончаков в районе исследования и по механическому составу относятся к рыхло-песчаным почвам.

В ходе исследования исчезновения водоема из-за некачественного обращения с отходами в горнодобывающей промышленности были изучены информационные и технические справочники по наилучшим доступным технологиям (техникам) из Российской Федерации, Европейского Союза и Казахстана. Тема использования вскрышных пород в качестве материала для засыпки выработанных карьеров и шахт для проведения компенсационных работ была специально изучена с целью уменьшения антропогенной деформации ландшафта и ущерба окружающей среде. ИТС 16–2023 «Горнодобывающая промышленность. Общие процессы и методы» содержит информацию о применении вскрышных и вмещающих пород [6, с. 78]. Некоторые стратегии обращения с промышленными отходами включают заполнение пустот горной массой, получение строительных материалов и планирование утилизации и обогащения отходов горной промышленности.

Использование обратного размещения извлеченных пород является наилучшей практикой, поскольку это помогает предотвратить или уменьшить образование отходов горных работ, а также обеспечивает рекультивацию территории путем запрета на отчуждение новых земель для сбора, хранения и утилизации отходов [6, с. 78].

Обратная засыпка — это процесс заполнения выработанного пространства шахты материалами. Она используется для следующих целей в качестве альтернативы поверхностному размещению как при подземной, так и при открытой добыче полезных ископаемых:

- Подземная разработка направлена на обеспечение стабильности грунта, уменьшение просадок, обеспечение безопасности кровли и улучшение вентиляции;
- Разработка открытым способом направлена на восстановление ландшафта и поддержание безопасности сооружений, таких, как карьер.

Существует четыре разновидности действующих обратных закладок: сухая, цементирующая, гидравлическая и пастообразная [6, с. 80].

Вскрышные породы и пустая порода могут приносить экономическую выгоду за счет производства заполнителей (щебня). Возможность производства строительных минералов в значительной степени зависит от наличия на местных рынках материалов определенного качества (например, соответствующих стандартам и разумных транспортных расходов). Эти установки используются в строительстве, в дорожном строительстве, в гражданском строительстве, для защиты побережья и для самостоятельного строительства. Инертные отходы (по определению) не создают проблем для окружающей среды; но неинертные и неопасные горные породы могут использоваться по определенным причинам, например, в качестве фундаментов при дорожном строительстве. Это определяется их индивидуальными особенностями, технологическими, экономическими и экологическими требованиями. Некоторые

строительные минералы также могут быть использованы в коммерческих целях в химической промышленности [6, с. 81].

Переработка старых отходов горнодобывающей промышленности — это давняя практика, которая применяется ко всем видам полезных ископаемых, включая энергетику, металлические руды, промышленность и строительство. Отходы с низким содержанием исходного минерала, которые в настоящее время хранятся в хвостохранилищах или отвалах, перерабатываются с получением готового продукта, такого, как металл, щебень (заполнители), уголь (для энергетических полезных ископаемых) и так далее. Технический прогресс сделал экономически целесообразным использование отходов прошлых горных работ в качестве ресурса [6, с. 82].

Для уменьшения образования отходов рекомендуется также проводить эффективные геологоразведочные работы.

Использование современных методов разведки (таких, как электрорезистивная томография (ERT), георадар (GPR) и т.д.) или математическое моделирование местоположения массива полезных ископаемых позволяет избежать крупномасштабного бурения; предоставлять ответы о качестве и рыночном спросе на продукт на основе его характеристик; оптимизировать объемы добычи за счет локализации зон залежей. Надлежащие характеристики ресурсов и отходов при добыче полезных ископаемых, а также предварительное планирование добычи обеспечивают эффективное извлечение и стерилизацию ресурсов (т.е. способствуют доступности исходного сырья в будущем) [6, с. 79].

В руководстве представлен полный перечень наилучших доступных технологий (НДТ), направленных на снижение воздействия отходов горнодобывающей промышленности на окружающую среду. Среди этих методов особого внимания заслуживает НДТ 5.8.12. Эта конкретная технология предполагает использование подземных отходов для различных эксплуатационных и производственных целей, таких, как укрепление откосов, засыпка карьерных дорог и рабочих площадок, а также использование в качестве взрывного материала. Кроме того, это облегчает обслуживание инфраструктуры, помогает в закрытии шахт, поддерживает усилия по рекультивации земель и вносит свой вклад в производство строительных материалов. Используя этот подход, можно сократить объем удаляемых отходов, что приведет к уменьшению площади земельных участков, необходимых для размещения свалок и, следовательно, к минимизации воздействия на окружающую среду [6, с. 21].

В документе MTWR BREF (ЕС-JRC 2009) предлагается следующий приблизительный диапазон затрат на утилизацию отходов добывающего сектора: от 0,3 до 0,8 евро за т, в зависимости от расстояния транспортировки (15 или 100 км соответственно) [21].

При той же продолжительности транспортировки дешевле возвращать отходы горной промышленности в выемочный карьер на поверхности, чем подготавливать новое место для захоронения отходов горной промышленности (включая свалку).

Заклучение

Следует отметить, что исчезновение озера Сорколь было доказано как данными спутниковых снимков Google Earth, так и синтезированными картами значения индекса NDWI. Использование биоиндикации и маршрутных методов позволило выявить основные экосистемы на территории бывшего озера Сорколь, а также описать характер растительности и животного мира на исследуемой территории. Из приведенных выше данных следует, что экосистема озера полностью изменилась на луговую. Этот факт подтверждается растительными сообществами и следами жизнедеятельности представителей животного мира. Наилучшей доступной технологией для решения подобных ситуаций является обратная засыпка пустых пород.

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Тау-кен қалдықтарын басқарудағы экологиялық оқиғалар

Аңдатпа. Жұмыста Шаймерден карьері мен бұрынғы аумақты геоэкологиялық зерттеу жүргізілді Соркөл көлі. Кенді өндіру кезінде экологиялық оқиғалардың пайда болуын болдырмау үшін ең жақсы қолжетімді технология ұсынылады. Зерттеудің ғылыми жаңалығы қорғасын-мырыш кенін өндірудегі техногендік қызмет нәтижесінде су объектісінің жойылу құбылысын сипаттаудан тұрады. Шаймерден кенішінің түбіндегі топырақ шөгінділері зерттелді. Бұрынғы түбіндегі шөгінділерден топырақ сынамаларының үлгілері зерттелді химиялық талдау. Нәтижесінде топырақ бейтарап ортаға ие. Топырақ қатты тұздалған, тұздану түрі сода, бұл тығыз қалдықтың, электр өткізгіштігінің маңыздылығымен дәлелденеді. Топырақта гумус аз, бірақ топырақ қол жетімді түрде қоректік заттарға бай. Тыңайтқыш ретінде топырақтың құрамдас бөлігі ретінде пайдалануға болады. Бірақ карбонаттар мен гидрокарбонаттар өсімдіктер үшін ең улы болып табылады. Качинскийдің гранулометриялық құрамы Жеңіл. Жалпы алғанда, топырақ көрсеткіштерінің сипаты топырақтың бірнеше жыл бойы сумен жабылмағанын көрсетеді.

Түйін сөздер: Экологиялық Кодекс, геологиялық барлау жұмыстары, қоршаған ортаны қорғаудың бірыңғай ақпараттық жүйесі, ең жақсы қолжетімді технология, тау-кен өнеркәсібінің қалдықтары, ірі экологиялық оқиға, пайдалы қазбалар кен орындарын барлау.

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Environmental incidents in mining waste management

Abstract: The present study represents the geo-ecological investigation of the the Shaimerden open pit mine area and the former Sorcol Lake. It was advised to use the greatest technology to avoid environmental mishaps when extracting ore. The study's scientific uniqueness resides in its explanation of the phenomena of water bodies disappearing due to technological operations involved in lead-zinc ore mining. Soil samples from former sediments were examined for chemical analysis. In general, the nature of the soil indicators indicates that the soil has not been covered with water for several years. Bioindication and route methods were used to confirm the change of the aquatic ecosystem to the meadow one. World life, including foxes and hares, were recorded as signs, and the absolute dominant among the vegetation species is the Bassia. Using cartographic methods, the dynamics of the disappearance of the reservoir was visually captured. The results allowed us to make an assumption that the drying of the water body is associated with the activity of the Shaimerden quarry.

Keywords: Environmental Code, geological exploration, unified information system for environmental protection, the best available technology, waste from the mining industry, a major environmental accident, exploration of mineral deposits.

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An Emerging New Tourism Destination: Geographic Resources and Tourism Potential of the Province of Masbate (Republic of the Philippines)

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Abstract. The Masbate Province surrounded by the Sibuyan Sea, Visayan Sea and Samar Sea, is located in the central part of the Philippine archipelago and includes 3 large islands (Masbate, Ticao and Burias) and many smaller islands. All the islands within the borders of Masbate Province are just one part of the Luzon Islands Group in terms of physical geography; also, in terms of political geography and administrative geography, they are located within the “Bicol Administrative Region”. In terms of administrative structure, there are 20 districts, 1 city (Masbate City) and 550 Barangays in the Masbate Province. Even though the Masbate Province has rich natural resources and mines, great agricultural and fishing potential, it has so far failed to achieve the desired success in international tourism. In this study, Masbate, Ticao and Burias, which are the largest islands of the Masbate province, are investigated and analyzed separately and both their geographical features, tourism potential and tourism attractiveness of these islands are accounted for. In this article, the main accommodation facilities, major nature reserves, islands and beaches within the borders of Masbate Province, as well as natural and cultural tourism attractions are examined; additionally, the tourism advantages and disadvantages of Masbate Province are addressed. The main purpose of the study is to introduce the tourism resources, cultural riches and natural beauties of the Masbate Province, which actually is not very popular among the international tourists, to the readers, both to popularize the name of the Masbate Province to the global tourism markets and offer new holiday options for the inquisitive tourists.

Keywords: Masbate Province, Tourism Attractions, Republic of Philippines, International Tourism, Philippine Archipelago.

Introduction

Located in the central part of the Philippine archipelago, Masbate Province includes 3 large islands and many small islets. “Masbate”, “Ticao” and “Burias” are the largest islands of Masbate province in terms of both area and population (Figure 1). Deagan, Hamurawon, Rakit Dakit, Magcaraguit, Matabao, Bugtong, Tatus, Bosaan, Napayawan, Nabuktot, Majaba, Carogo, Jintotolo, Tagauayan, GUILITUGAN, BUABUAHAN, AMBULONG, BUSING, BAGABABOY, YESO, PURO Other important islands are Cagpating, Tatus, Chico and Pobre (Table 1). But among the international tourists, the most popular touristic islands in the province are undoubtedly Sombrero, Tinalisayan, San Miguel, Dapa, Magcaraguit, Balangingi, Tagauayan, Butod and Animasola. The Masbate Province, situated within the borders of the Bicol Region, includes 20 counties, 550 barangs, more than 30 towns and 1 urban settlement (<http://masbate.gov.ph/>).

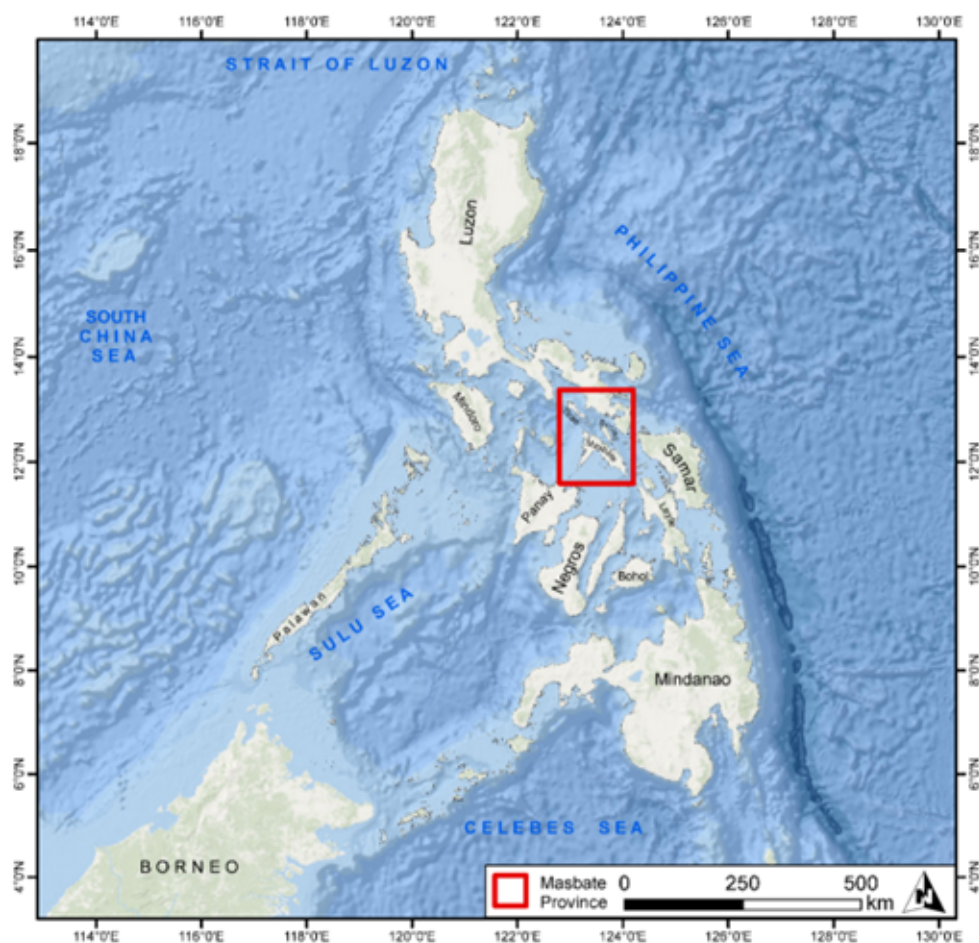


Figure 1. Location Map of the Province of Masbate

(Source: Authors, 2022)

The Masbate Province, situated in the central part of the Philippine archipelago, is composed of 3 large islands and many small islets. “Masbate”, “Ticao” and “Burias” are the largest islands

of the Masbate province in terms of both area and population. Deagan, Hamurawon, Rakit Dakit, Magcaraguit, Matabao, Bugtong, Tatus, Bosaan, Napa yawan, Nabuktot, Majaba, Carogo, Jintotolo, Tagauayan, Guilitugan, Buabuahan, Ambulong, Busing, Bagababoy, Yeso, Puro, Chicopating, Tatus Ca and Pobre situated within the province are the other important islands (Table 1). However, the most popular touristic islands in the province among the international tourists are undoubtedly Sombrero, Tinalisayan, San Miguel, Dapa, Magcaraguit, Balangingi, Tagauayan, Butod and Animasola. The Masbate Province situated within the borders of the Bicol Region, includes 20 districts, 550 barangs, more than 30 towns and 1 urban settlement (<http://masbate.gov.ph/>). The Masbate Province, which has three different coasts, is separated from the island of Luzon by the Ragay Bay in the north and the Burias and Ticao straits in the east. The Masbate Strait separates the islands of Ticao and Masbate. Masbate Province is surrounded by the Visayan Sea to the south, the Samar Sea to the east, and the Sibuyan Sea to the west (Chirikov et. al., 2008). The Masbate Province, adjacent to the provinces of Colonel, Sorsogon, and Camarines, Sur does not have high mountains, great lakes, long streams, and metropolitan cities. Low hills and plateaus, valleys and plains are the most common landforms within the province.

Table 1. Primary Characteristics of the Masbate Province

Group Islands Located: The Luzon Group Islands		The Region: Bicol Region
Surface Area: 4138 km ² Total Population: 908 920 (Year 2020)		Mathematic Location: 12°43' – 13°25' north latitude 123°09' – 124°5' east latitude
The Highest Point: Conical (697 m) The Longest River: Lanang The Largest City: Masbate City The Largest Bay: Asid The Largest Lake: Calero The Largest Province: Milagros		Major Nature Reserves: “Halea Nature Park” “Bongsanglay Natural Park” “Buntod Sandbar and Reef Marine Sanctuary” “Chico Island Wildlife Sanctuary” “Manta Bowl Marine Protected Area”
Number of Barangays Embodied: 550 Number of Municipalities: 20		Arithmetic Population Density: 220 people/km ²
Big Islands: Masbate, Ticao, Burias, Deagan, Hamurawon, Rakit Dakit, Magcaraguit, Matabao, Bugtong, Tatus, Bosaan, Puro, Napayawan, Nabuktot, Majaba, Jintotolo, Yeso, Tagauayan, Busing, Guilitugan, Guinauayan, Paltaban, Balangingi, Buabuahan, Carogo, Chico Island, Ambulong, San Miquel, Bagababoy and Cagpating.		The Largest Settlements: Masbate City, San Pascual, Mobo, Claveria, Monreal, San Jacinto, Batuan, San Fernando, Aroroy, Placer, Esperanza, Baleno, Mandaon, Milargos, Uson, Dimasalang, San Rafael, Palanas, Cataingan, Pio V. Corpuz, Cawayan, Guiom, Palanas, Masbaranon, Cabayungan, Tugbo, Uson, Tigbao, Buenavista, Mintac, Magsalangi and Balud.

(Source: Authors, 2022)

The Masbate Province has rich natural resources and mines. Crop production, fishing, tourism, mining, cattle breeding and poultry farming are the most developed economic

branches of the province. Copra production and gold mining generate enormous income to the province's economy. Food and oil industry, clothing and textile industry, ceramic industry and fish processing, metalworking and handicrafts, forest products and furniture production are also the economic activities in the province. Rice, maize, bananas, tobacco, sugarcane, copra, root crops and coconuts are widely grown on the province's fertile farmland. Masbate is described as a province that sits on a "pot of gold" by the geologists. The province has rich minerals and a wide variety of mineral deposits. The Masbate Province has rich reserves of manganese, copper, silver, iron, chromium, gold, coal, limestone and carbon (<https://www.philatlas.com> ; <http://psa.gov.ph/>).

There has been a rapid population growth in the province's population in the last century. The population of Masbate Province, which was 67 513 in 1918, increased to 211 1132 in 1948, 492 908 in 1970, 599 355 in 1990, 707 668 in 2000 and 908 920 in 2020. (<https://www.philatlas.com>; <http://psa.gov.ph/>). Today, the population of Masbate Province alone constitutes 14.94% of the population of the Bicol Region, 1.46% of the population of the Luzon Islands Group, and 0.83% of the population of the Republic of the Philippines. Even though English and Tagalog are the most common languages in the Masbate Province, as in every Philippine province, the local people prefer the local languages for communication among themselves. The Masbateño, Hiligaynon, Cebuano, and Waray languages are the most widespread spoken-vernaculars within the province. 91% of Masbate Province's population is Catholic Christian. The total share of Protestant Christians, Buddhists, Hindus and Muslims within the provincial borders is less than 5% of the province's population (<https://www.philatlas.com>; <http://psa.gov.ph/>).

Table 2. Major Administrative and Geographical Features of the Masbate Province (<https://www.philatlas.com/>)

Name of the Province	Population of the District (Year 2020)	Surface Area (km ²)	Population Density (person/km ²)	Number of Barangays Embodied
Aroroy	88 351	440,30	201	41
Baleno	28 855	204,38	141	24
Balud	40 155	231,00	174	32
Batuan	14 610	56,28	260	14
Cataingan	50 623	191,64	264	36
Cawayan	69 265	260,19	266	37
Claveria	42 142	182,98	230	22
Dimasalang	24 909	148,07	168	20
Esperanza	17 534	67,49	260	20
Mandaon	44 122	319,15	138	26
Masbate City	104 522	188,00	556	30
Milagros	57 538	565,30	102	27
Mobo	40 823	143,47	285	29

Monreal	25 164	128,67	196	11
Palanas	27 322	119,53	229	24
Pio V. Corpuz	23 744	89,33	266	18
Placer	56 340	193,03	292	35
San Fernando	21 600	77,50	279	26
San Jacinto	29 686	122,40	243	21
San Pascual	44 449	246,65	180	22
Uson	57 166	163,20	350	35
TOTAL	908 920	4 138	220	550

There are 20 districts, 1 city (the Masbate City) and 550 Barangays in the Masbate Province (Table 2). Milagros (565.30 km²) and Aroroy (440.30 km²) are the districts with the largest surface area of the province. Batuan (56.28 km²), Esperanza (67.49 km²), San Fernando (77.50 km²) and Pio V. Corpuz (89.33 km²) are the districts with the smallest area in the province. As a result, only 2 districts have an area of greater than 400 km² within the province borders and only 4 districts have an area of less than 100 km² (Table 2).

Materials and methods

This research was conducted using the case study method. Data and information obtained from document analysis and semi-structured interviews, as well as field observations, focus group discussion, participant observation, and expert interviews were used. Case studies are defined by many different names in different countries. A case study is one of the types of systematic design that involves steps such as gathering information, organizing, interpreting, and researching the information gathered, and achieving results, just like detailed planning in architecture. Case studies are a way to see what is actually happening in the environment, systematically collect data, analyze it, and draw conclusions. The result is a clear understanding of why things happened the way they did and what to focus on in detail for future investigations. In this study, “embedded single case study design”, in which there are more than one sub-unit of analysis, was used. In the planned research, both illustrative case studies, exploratory case studies and observational case studies were applied together.

This scientific study, which is part of the research program titled “The Republic of the Philippines from the Perspective of Political, Economic and Human Geography and Turkey-Philippines Interaction”, which was accepted by the Scientific and Technological Research Council of Turkey in 2020 within the scope of “2219-Overseas Postdoctoral Research Scholarship Program” and conducted by Emin Atasoy is one of its scientific outputs of this program. In the present study, the demographic, geographical, economic and ecological characteristics of the Masbate Province was examined, and both the tourism advantages and disadvantages as well as the tourism resources of the island were attempted to be identified. The author (Emin Atasoy) conducted city surveys and geographical observations on the Masbate Province between 15 January 2023 – 26 January 2023; as a result, he personally examined majority of the tourism

centers on the island. The methodological basis of the study is the methods of a systematic scientific approach, comparative geographical, cartographic and expert assessment. One of the primary aims of this study is to announce the tourism power of this little-known province to the world and to introduce the province's tourism attractions to the inquisitive travelers and readers.

The principle aims of this study are:

● Masbate Province is a geographical location that is not well known to the tourism experts and is not very popular with the international tourists. Therefore, the main purpose of this article is to reveal the tourism richness of the province with this scientific study and announce both tourism centers and natural beauties to the whole world.

● To introduce the readers to the geographical features, natural resources and regional differences of the Masbate Province.

● To introduce the readers to the tourism resources, natural beauties and tourism potential of the Masbate Province.

● To discuss the tourism privileges, tourism advantages and tourism disadvantages of the Masbate Province.

● To identify and examine the main natural and cultural tourism attractions of the Masbate Province.

● To create a tourist reference guide for the international tourists visiting the Masbate Province.

● To paint a multidimensional tourism portrait of the Masbate Province and make a scientific presentation of the island from the perspective of tourism geography.



Figure 2. Administrative Map of the Masbate Province

Result and discussion

The following separately examines the largest islands of Masbate province, “Masbate”, “Ticao” and “Burias” and separately explicates both geographical and touristic features of these islands. These three islands have been examined from the perspective of tourism geography under 3 main headings:

- A) General Geographical Characteristics of the Island,
- B) Tourism Potential of the Island,
- C) Major Tourism Attractions of the Island.

General Geographical Characteristics of the Masbate Island

Within the borders of the Republic of the Philippines, there is a district, an airport, an island, a city, a port, and a province by the same name ‘Masbate’. Undoubtedly, the area of Masbate province is much larger than the island of Masbate. It is because, apart from “Masbate”, “Ticao” and “Burias”, there are around 20 other islands within the borders of the province. Located in the central part of the Philippines, the island of Masbate is part of the Luzon Islands Group and is the country's 11th largest island in terms of surface area. The surface area of the Masbate island is 3269 км² and there are 14 districts and 1 city settlement within the borders of the island. Moreover, more than 740,000 people live on the island (<https://www.philatlas.com>; <http://psa.gov.ph/>). There is not a single metropolitan city on the island of Masbate, which has an area of approximately 10 times larger than the island of Siquijor, and there is no other city settlement other than the Masbate City. The Masbate Island, which has a central location within the borders of the Philippine Republic, is surrounded by many large islands and has sea transportation connections with many ports due to the heavy passenger/tourist traffic. Thus, it is explicit that the Masbate province maintains sea transport links and regular ferry services for passengers with the islands of Luzon, Cebu, Leyte, Mindanao, Sibuyan and Samar. The most important and busiest port in the Masbate province undoubtedly is the sea port in Masbate City (Alonzo, et al., 2007).

In other words, there are regular ferry services from the sea port in the Masbate City to 8 ports of Luzon island, from 2 ports of Leyte island, from 1 port of Samar island, from 2 ports of Mindanao island, from 1 port of Ticao island, from 2 ports of Cebu island, from 1 port of Bugtong island and from 1 port of Sibuyan island throughout the year (<https://www.philatlas.com>; <http://psa.gov.ph/>). It is possible to argue that the transportation links between the islands within the provincial borders are not well developed and are insufficient. Within the province, regular ferries run only between the island of Masbate and the islands of Ticao and Bugtong and they are very inadequate as well. As a whole, the fact that the Masbate Island has maritime transport links with around 10 islands and around 20 ports is undoubtedly a great advantage for the development of tourism activities. Basically, it is explicit that the maritime transport links between the Masbate Province and other provinces are substantial and adequate, but the maritime transport links within the province are weak and inadequate (Alonzo, et al., 2007).

Consequently, since the Masbate Province, which has only one airport, does not have a rail transportation option, the road and sea transportation are the only options for the domestic and international tourists to arrive in Masbate. It should be emphasized that the only transportation option, which is of vital importance both between the islands and the provinces, is the sea transportation connections. The most important and busiest ports found within the borders of the Masbate Province and still operating today are: Pio V. Corpuz, Masbate City, Cawayan, Cataingan and Aroroy ports on the Masbate island; the ports of Claveria and San Pascual on the island of Burias; Lagundi port on Ticao island and Bugtong port on the Bugtong island (Alonzo, et al., 2007).

There are many gulfs, peninsulas, cliffs and atolls on the island of Masbate, which has indented and wavy coasts. Laoc, Nin, Alas, Antabaan and Malibon on the west coast; Mobo, Uson, San Agustin, Masbate, Naro and Cataingan located on the east coast are the largest bays of Masbate island (Chirikov et. al., 2008). There are many streams and rivers on the island of Masbate, but none of them are adequate for river transportation and their length does not exceed 80 kilometers. Most of the rivers on the island are the deep estuaries (Candelaria and Revale, 2010).

In the southern parts of the island, there are streams of the Daraga, Nainday, Guiom, Malburg and Nauco streams, whereas in the northern parts of the island, Lanang, San Isidro, Mataba, Baleno, Malbug, Bogtona, Agman, Casalog, Bangad, Agman, Goangalan, Narangasan, Calumangug, Jangan, Palani, Dayo, Napayawan, Taisan, Pinamangcaan and Manulib. The streams on the island are of vital importance for the people of Masbate in terms of both drinking water supply and agricultural irrigation. Both the Masbate Province and Masbate Island have very few lakes. "Matayum Lagoon", "Calero" and "Mintac Blue Lagoon" are the largest lakes of the Masbate island (Velza et. al., 2022). Calero Lake, situated just east of the town of Uson, is a touristic lake visited by holidaymakers and families having picnics, especially at the weekends.

The Masbate island is bordered by the Sibuyan Sea to the west, the Visayan Sea to the south, and the Samar Sea to the east. Therefore, it is explicit that the island has 3 different coasts. The Gulf of Acid, located in the south of the island, has helped the island to have an inverted "V" shape. The maximum height of the island, devoid of high mountains, does not exceed 700 meters. While the low plateaus, coastal plains, river valleys, hilly lands and plains cover large areas throughout the island, it is clear that the mountainous and rugged lands cover very little area. The highest mountains of the island are: Conical (697 m.), Bagulipat (604 m.), Uac (592 m.), Nabongsuran (484 m.), Banco (433 m.), Manapao (373 m.) and Mabilantack (176 m.) (Chirikov et. al., 2008).



Figure 3. Tourism Map of the Masbate Province (Source: Authors, 2022)

While most of the villages and towns on the island of Burias and Ticao are located on the coast, the Masbate island has the opposite situation because more than 70% of the rural settlements are located inland, away from the sea coast. In terms of tourism and maritime transport activities, Aroroy, Cataingan, Pio V. Corpuz, Placer, Esperanza, Cawayan, Mandaon, Uson, Milargos, Pulanduta, Mobo, Balud and Baleno are the most important and busiest town settlements on the island of Masbate (Chirikov et. al., 2008). The Masbate City, the largest settlement and only city on the island of Masbate, is also the capital of the Masbate province. The Masbate City is the most important and busiest transportation, commerce, culture, education and tourism center of both the island and the entire province. The “Masbate Airport” situated within the boundaries of the Masbate City, is the province's most strategic transportation hub in terms of transportation links between the Philippine islands and international tourism.

Tourism Potential of the Masbate Island

The Masbate island is not one of the most important tourism centers of the Philippines, nor is it one of the most visited or most wondered islands of the country. In fact, even though this

island has a very high tourism potential, it is possible to argue that it has only recently been introduced and promoted in the international tourism markets. The Masbate Island is one of the Philippine islands that has suffered the most vegetation destruction, lost the most natural forests and is most adversely affected by the mining activities. Therefore, erosion, deforestation and mining problems emerge as the environmental problems throughout the island (Candelaria and Revale, 2010). The adverse ecological conditions also negatively impact the tourism activities throughout the island.

Therefore, when compared to the islands such as Negros, Palawan, Bohol and Cebu, the number of beaches, restaurants, hostels and hotels as well as other touristic facilities is much less on the Masbate island. Nevertheless, it should be noted here that Masbate is both the island with the largest surface area, the island visited by the largest number of tourists and the island with the most touristic centers within the borders of the Masbate province. Beaches, caves, historical churches, agricultural farms, waterfalls, nature protection areas, cute little islands, lighthouses, lagoon lakes, long beaches and hidden coves are the most important tourism attractions of the Masbate Island.

Even though there are many beach areas within the borders of the Masbate island, the most popular ones among local and international tourists are: "Pulanduta Backyard Beach", "Karigo Beach Resort", "ACE Palani Garden Beach Resort", "Barangay Palani Beach", "Bernabela Beach Resort", "Puert Verde Beach", "Nailaban Beach Front", "Apar Beach", "Tinigban Beach", "Tinago Park", "Lucky Beach Resort", "Corong Beach Resort", "Pirate Beach", "Punta Beach", "Naome's Beach Resort", "Carandang Beach Resort", "Shining Star Beach Resort", "Hayahay Beach Resort", "Curvada D' Jamon", "Bamboo Groove", "Licuson Beach", "Bituon Beach Resort", "Dora Beach Resort", "Porta Vega Beach", "Bontod Sanbar", "Poctol Beach", "Rosas Beach", "Khokak Beach Resort", "Matayum Lagoon", "Playa de Gregorio Beach", "Dako'ng Baybay Beach", "Talisay Beach Resort", "D'Siblings Beach Resort" and "Cabatibgan Beach Resort". (Table 3).

There are more than 10 historical churches from the Spanish colonial period within the borders of the Masbate island. The "Our Lady of Remedies Parish" situated in the town of Placer, the "St. Roche Parish Church" in the town of Pio V. Corpus, the "Theotokos Orthodox Church" and "Holy Spirit Chapel" located in the town of Cataingan, the "San Antonio de Padua Cathedral" and "Diocese of Masbate Church" located in Masbate City are the most popular and most visited religious centers by the tourists on the Masbate island (Table 3). All in all, Masbate is the most developed island of the province in terms of both tourism resources and tourism potential. In Table 3 presents the tourism attractions that are situated within the borders of the island and that the domestic and international tourists are most interested in visiting.

Table 3. Top 25 Natural and Cultural Tourism Attractions of the Masbate Island

Top 25 Natural Tourism Attractions of the Masbate Island	Top 25 Cultural Tourism Attractions of the Masbate Island
Mintac Blue Lagoon (Cataingan)	Mangrove Forest Park (Masbate City)
Bat-ongan Cave (Mandaon)	San Antonio of Padua Cathedral (Masbate City)
Porta Vega Beach (Dimasalang)	Bugui Point Lighthouse (Aroroy)
Buntod Sandbar and Reef Marine Sanctuary	Rodeo Masbateño Grand Arena (Masbate City)

Palani White Beach (Balud)	Theotokos Orthodox Church (Cataingan)
Pawa Mangrove Park (Masbate City)	D'Siblings Beach Resort (Placer)
Busay De Gracia Falls (Baleno)	Diocese of Masbate Church (Masbate City)
Mount Mayong Payong (Mobo)	Panique Lighthouse Christian Church (Aroroy)
Magcaraguit Island (Dimasalang)	Velarde's Mountain Resort (Balud)
Tagauayan island (Cawayan)	Punta Bugui Lighthouse (Aroroy)
Tinigban Beach (Aroroy)	Mangrovetum Eco Park (Masbate City)
Pulanduta Backyard Beach (Balud)	St. Roche Parish Church (Pio V. Corpus)
Bentongan Creek (Balud)	Our Lady Of Remedies Parish (Placer)
Luacan Water Park (Milagros)	Cabatingan Beach Resort (Cawayan)
Chico Island Wild life Sanctuary	Burdz Berry Garden (Uson)
Jamorawon Pink Beach (Dimasalang)	Winter's Farm Resort (Milagros)
Rosas Beach (Cataingan)	Mt. Moriah Prayer Mountain (Masbate City)
Matayum Lagoon (Cataingan)	Naome's Beach Resort (Baleno)
Balangingi Island (Pio V. Corpus)	The Garden Landscape Park (Cataingan)
Busay de Gabi (Baleno)	Jintotolo Lighthouse (Balud)
Ubo Falls (Masbate City)	Gaisano Capital (Masbate City)
Kristel Beach Resort (Balud)	Magcaraguit Resort (Dimasalang)
Deagan Island (Dimasalang)	Curvada D' Jamon (Masbate City)
Hamurawon Island (Dimasalang)	Acean Sea Front Acenak Haws (Milagros)
Nailaban Beach Front (Mandaon)	Holy Spirit Chapel (Cataingan)

(Source: Authors, 2022)

The geographic distribution of hotels and accommodation facilities in the Masbate Province shows a great imbalance. There are around 150-160 accommodation establishments in the entire province, of which more than 90% are beachfront hotels. More than 80% of the hotels in the province are located on the Masbate Island (Table 4), there are more than 40 accommodations especially in the provincial capital of the Masbate City and its immediate surroundings. While around 35 accommodation facilities are active on the island of Ticao, there are only about 10 accommodation facilities in Burias, which is the poorest island in terms of hotels. Therefore, it is clear that within the borders of the province, Masbate has highest and Burias has the least number of accommodation facilities. There are hardly any four and five- star hotels in the luxury class in Masbate. Low-priced hotels, hostels, apartments, hostels, motels, rental villas, and family businesses are the most common accommodation facilities within the province. The “Treasure Island Hotel”, “Unica Hija Hotel and Resort”, “Carlton-Martin Hotel”, “Bahia Vista Resort”, “Gagay's Hotel & Resort”, “Playa de Gregorio” and “Beatriz Rafaela Resort” are found within the provincial borders can be cited as the examples of a small number of quality accommodation facilities (Table 4). Consequently, the Masbate Province is lacking in the luxury accommodation facilities, nor does it have any modern hospitals and arts centers, multi-purpose sports complexes, theaters and modern cultural centers.

Table 4. Major Accommodations on the Masbate Island

Villa Carillo Beach Resort	Bitlig Beach Resort	Ponce's Resort
Renzales Beach Resort & Restaurant	Camp Elizabeth Resort	D.A. Resort Hotel
D'Siblings Beach Resort	Prolex Beach Resort	Aballe Homes
Abejo Snack Inn & Lodge	Roque Residence	Sitio Salvame
Ramos Beach Resort	Jomajejan Garden	Balud Resort
Riza Olaran Beach Resort	Floresta Sun Rise Hotel	Balud Lodge
Ajam's Logde and Boarding House	DJ Guesthouse Hotel	Vivo 1820
Nancy Ado Boarding House	Coco Beach Resort	Coco View Lagoon
Paraiso de Palani Beach Villas	Winter's Farm Resort	Emily's Place
RL Horizon Beach Resort	Shaira's Beach Resort	D's Lodge
Beatriz Rafaela Resort	Star Beach Resort	Tito A's Place
Bernabela Beach Resort	Morning Sun Tourist Inn	Papa Ed's Beach
Previn Bleu Resort & Cabana	Villa Candelaria Resort	Solis Residence
O' Manor Apartment Hotel	Barrios Beach Resort	Casa Editha
Sol Celeste Beach Resort	Tinay Relano Residence	Meljefson Domingo
Hidden Cove Manoboc Beach	Corong Beach Resort	Uma Koinonia
Jelan Beach & Pool Resort	Naome's Beach Resort	Albhen's Resort
Sea Bliss Bed and Breakfast	Bituon Beach Resort	White's Beach
Chona and Christophe Guesthouse	Umaroy Beach Resort	Ananor Otel
Mt. Moriah Prayer Mountain	Karla Beach Resort	Patio Milagros
Ambak - Tubig sa Macahilao	Bahia Vista Resort	Abela - Padecio
Privado Accomodation And Reservation	Mama's Dorm & Lodge	Rosas Beach
D'HillsView Hotel & Restaurant	Casa de Soledad	El Fujds
D Ark Hotel and Restaurant	Bing Oling Building	Ross Hotel
Panas Bay Infinity Pool Resort	Treasure Island Hotel	Novo Hotel
St. Anthony Hotel & Restaurant	GV Hotel Masbate	JL Hotel
Team Centrum Seamans Hotel	D'bluewave Resort	Road To Glory
Unica Hija Hotel And Resort	Mac John Cattage	Rancher's Hotel
Jimcre Hotel And Restaurant	Playa De Gregorio	Cherish Resort
Rendezvous Hotel And Beach Resort	Sabine's Place Masbate	Baywalk Hotel
7AR Golden Beach Resort	Bambi Pension House	Kendrick Joseph
Greenview Hotel and Restobar	Safe House Residence	Velasco Inn
Boarding House ni Erwin	Chichay Resort Hotel	Circle E Hotel

(Source: Authors, 2022)

Major Touristic Attractions of the Masbate Island

Unquestionably, the most touristic resorts and hotels and the most touristic attraction in the entire Masbate province are situated on the Masbate island. The historical churches and lighthouses, majestic waterfalls and caves, breathtaking beaches and touristic islets, moist mangrove forests and interesting coastal formations, natural wonder lagoon lakes and colorful coral reefs are among the most common touristic attractions on the Masbate island. The following briefly describes the main touristic attractions on the Masbate Island and its surroundings.

● Buntod Sandbar and Reef Marine Sanctuary

Unmistakably, "Buntod Sandbar and Reef Marine Sanctuary" is one of the most beautiful places in the Masbate province. This interesting marine protected area, found between the Masbate and Ticao islands, is located a few kilometers east of the city of Masbate. The marine protected area, situated just north of Mobo Bay, fascinates visitors with its sand islets, white beaches, coral reefs, and breathtaking beaches. This conservation area is easily accessible by a 20-minute boat ride from the pier at the Rendezvous Hotel. The park area has very suitable natural features for those who wish to sunbathe on the beach, swim in the sea, explore the mangrove forests, take a walk on the shallow sea shore or on the beach. In an attempt to preserve this natural miracle for centuries and pass it on to the future generations, the Filipino authorities created a special marine protected area covering a surface area of 250 hectares and placed it under the province protection (Velza et. al., 2022). That is why the "Buntod Sandbar and Reef Marine Sanctuary" is known as the most famous and most beautiful marine sanctuary on the Masbate island. Thousands of tourists visit this marine protected area every year because of its shallow sea coast, long and clean beaches, breathtaking reefs, turquoise clear waters suitable for snorkeling, rich species of wildlife, and geographical proximity to the provincial center (Calumpong, et. al., 2013.).

● Palani White Beach

The "Palani White Beach", located on the southwest coast of the Masbate island, 2-3 kilometers north of the town of Balud, is the island's most popular, beautiful and white sand dunes. The long stretches of the beach are so enchanting and so white that many experts compare it to the famous "White Beach" in Boracay. The natural beach area stretching for about 10 kilometers is tranquil, clean and relatively unspoiled. The gradually deepening sea shore and generally calm waters of the beach area are perfect for swimming. The best part of this beach is that it is located in a calm, tranquil, clean bay with its magnificent sunset view. The fact that the Palani region is far from big cities, that there are no factories and industrial facilities that ruin the environment in the immediate vicinity, and that it is outside of the international mass tourism routes has provided a great advantage to the beach area and the local region. The crystal clear waters of "Palani White Beach" within the borders of Balud district are so tantalizing that one cannot help throwing oneself into the sea. In a solitary cove on the shores of the Visayan Sea, the beach area surrounded by coconut trees offers affordable accommodation to the visitors with several nipa huts. The wide and long white sandy beach is ideal for picnics, sunbathing, swimming as well as beach sports such as beach volleyball and Frisbee. Hotels such as "Star Beach Resort", "Paraiso de Palani Beach Villas", "Shaira's Beach Resort" and "RL Horizon Beach Resort" are active in the region where visitors can stay.

● **Busay De Gracia Falls**

“Busay De Gracia Falls”, situated within the borders of the Baleno district, is one of the mysterious and new touristic places newly discovered in Masbate and not even known by the locals. This majestic waterfall, located northwest of Masbate City and just southeast of the town of Aroroy, has just begun to make a name for itself among the enthusiastic travelers. The waterfall, which is situated on a gently sloping cliff, is a tourist attraction that is difficult to access as it is in a very remote place away from the main roads. 10-15 km away from the waterfall, there is no bakery or market, no pharmacy or restaurant, no hotel or pension around it. The river waters falling from different points has caused the emergence of many small waterfalls and created different terraces and different small natural pools. This waterfall, situated in a deserted area, is undoubtedly one of the most beautiful natural beauties of the Masbate Island.

● **Bat-ongan Cave**

The “Bat-ongan Cave” is one of the most popular and spooky tourist attractions in Masbate. The locals believe that this interesting cave was formed as a result of a meteorite that fell here millions of years ago. However, scientists do not support this assumption. The highest point of the cave, which has an underground river, is around 150 meters. There are many underground passages, many bats and various karst rock formations inside the cave. Up until now, the scientists have managed to discover 7 connection places between the earth and cave systems. The “Bat-ongan Cave”, situated in the northwest of Masbate island within the borders of Mandaon county, is a holy place that devout Christians usually visit during the Holy Week to find solitude, peace and contemplation. However, at the same time, the cave is open to individual visits, student-educational activities, group visits as well as scientific studies.

● **St. Anthony of Padua Cathedral**

This Historic Catholic Church known as “St. Anthony of Padua Cathedral” or “Cathedral-Parish of Saint Anthony of Padua”, is also referred to as the “Masbate Cathedral” among the Masbate people. This famous Catholic Church, located on Quezon street in the Masbate city and built in the Baroque architectural style, was founded in 1578 by the Spanish missionaries. Today, Masbate is both the administrative and religious center of the Roman Catholic Diocese. Even though this historical church, which reflects the Spanish culture and architecture, has undergone several serious renovations and repairs, it has managed to survive for centuries and continues to be one of the touristic symbols of the city of Masbate today. The St. Anthony of Padua Cathedral”, situated west of the city of Masbate and just east of the port of Masbate, is one of the most visited faith centers of both the city, the island and the Masbate province. This historic church is also one of the oldest Catholic Churches in the province of Masbate, as it started operating in 1578.

● **Chico Island Wildlife Sanctuary**

The “Chico Island Wildlife Sanctuary”, officially established on April 23, 2000, is one of the newest nature reserves both in the Masbate province and the Philippines. The Chico Island is a very small island located in the west of Masbate Island, southeast of the Gulf of Acid and northwest of Tagauayan Island. This islet, with a maximum height of only 5 meters above sea level, is home to about 2600 people. The “Chico Island Wildlife Sanctuary”, covering a certain part of this island and situated in the northeastern parts of the island, is a state-protected area

with an area of 7.7 hectares. This small nature reserve, found within the borders of Cawayan district, is of great importance in terms of environmental protection and sustainable ecosystems rather than tourism activities (Yambao et al., 2001). Preserving the rich diversity of plants and trees, as well as protecting the habitats and breeding grounds of migratory birds, is the primary duty of the “Chico Island Wildlife Sanctuary”. The Mangrove forests are the biggest ecological richness of this small nature reserve and the most common tree species in Kulasi, Pagatpat, Saging-saging, Bakawang lalake at babae, Tingal, Api-api and Buta-Buta nature reserve (Marie et. al., 2004; Velza et. al., 2022). The “Chico Island”, which does not have hotels and touristic facilities, is an islet suitable for daily picnics and short sea holidays. This quaint island can be reached by a charter boat from the town of Cawayan and both the migratory bird habitat and the island's mangrove forests can be inspected closely.

General Geographical Features of the Ticao Island

Ticao, situated in the central part of the Philippine archipelago and east of the Sibuyan Sea, is an underdeveloped and sparsely populated island that is not among the major tourist destinations of the Philippines. The Ticao island, which is located in the Luzon Islands Group, is found in the north and east of the Luzon island, the Burias island in the northwest, the Masbate island in the west and south, and the islands of Samar, San Vicente, Capul and Dalupiri in the southeast (Chirikov et. al., 2008). There are two important straits to its west: The Masbate Strait and Ticao Strait. The small islands such as Matabao, Tatus, Magcaraguit, Rakit Dakit, Hamoroan and Deagan, located in the south of the Ticao island, constitute a natural bridge between the island of Masbate and Ticao. To the north of the island of Ticao, there are small but important islands such as Cagpating, Yeso, Puro, Paltaban, Bagababoy and San Miguel. The “Halea Nature Park” and “Bongsanglay Natural Park”, which are visited by thousands of tourists every year, are the most important nature conservation areas of the Ticao island (Calumpong and Cadiz, 2012). The distance of Ticao island, which has a central location in the Philippine archipelago, to some neighboring islands is as follows: Burias island 110 km, Bantayan island 135 km, Sibuyan island 138 km. and Busuanga island 150 km. Undoubtedly, as the closest islands, Masbate and Burias are among the islands that most affect Ticao's economy and transportation connections.

Ticao, the 28th largest island of the Republic of the Philippines, has a population of approximately 100000 people and a surface area of 334 km². The maximum north-south length of the island is 39 km. whereas the east-west width is a maximum of 24 kilometers. The Ticao Strait, located east of the island of Ticao, separates it from the Luzon island (Chirikov et. al., 2008). The Masbate Strait, situated in the west of Ticao island, separates it from the Masbate island. In conclusion, the Ticao island is an underdeveloped island stretching in a north-south direction, sandwiched between the islands of Luzon and Masbate. There are 4 districts within the island borders: San Fernando, Batuan, Monreal and San Jacinto. There are no large lakes and streams on the island, and no hills or mountains higher than 400 meters. Therefore, it is possible to say that plains, flat places and slightly sloping areas are common throughout the island. The Mount Pandan (228 m.), the most popular touristic mountain on the island, is actually a low hill, not a geographical mountain (<https://www.philatlas.com>; <http://psa.gov.ph/>). The highest point of the island is an unnamed hill with a height of 386 meters, located northeast of the Togoron village and just south of the Cantorna village. The Danao lake is the only lake on the

Ticao island. There are around 15 short rivers that are not suitable for transportation within the borders of the island. Alisoso, Bagahanglad, Benahagan, Buho, Lajong, Mabini, Macugtong, Pandan, Piña, San Roque, Santa Rosa and Tutuban streams are the examples of the main streams of the Ticao island (Chirikov et. al., 2008).

Tourism Potential of the Ticao Island

Ticao, a calm, clean and peaceful tropical island, offers its visitors economical and quiet holiday opportunities with its crystal clear emerald waters and white sandy beaches. The coral reefs and islets around the Ticao island are abundant in colorful fish, stingrays, hammerhead sharks, great fox sharks and tiger sharks. Therefore, for scuba diving enthusiasts and ecological tourism lovers, Ticao is exactly the calm island they are after. Manta Bowl Shoal and San Miguel island are the most popular spots for scuba diving of Ticao. Furthermore, the tourists coming to the Ticao island should definitely visit the islands of Paborito, Cagpating, Matabao, Tatus, Bagababoy, Burubangkaso and Paltaban, which are situated in close proximity and have magnificent beaches. The tourists visiting Ticao generally come here for sea tourism and especially for diving. The lack of modern urban settlements, large shopping centers and comfortable hotels on the island has hindered the development of mass tourism.

Table 5. Major Accommodations on the Ticao Island

Ticao Tacdugan Beach Lodge	NBM'S Boarding House	Ticao Altamar
Lantau Baie Beach Resort	Altinel Beach Resort	Club de Ticao
Yuson Hotel and Beach Resorts	Orvens Lodging House	Lumonsod Rex
Reddoorz @ Ticao Island Resort	Koko Hauz Lodging Inn	Ticao Lodge
Ticao Lodge & Function Hall	Marceli Beach Resort	Bautista Resort
Binantayanan Beach Resort	Coolis Beach Resort	Serra Lodging
JPS Beach Resort & Convention Center	Pujol Lodging House	Cocohauz
Ula Lozano Lodging House	Barruga Beach Resort	Looc Beach Resort
Zandra’s Beach and Convention Center	Rai Son Private Beach	Ticao Island Resort
Floresta Sun Rise Hotel	S&C Beach Resort	Gibraltar
Villa Teresita	3f Tourist Inn	Grona's Inn

(Source: Authors, 2022)

Even though there are around 35 hotels and accommodation facilities operate on Ticao Island, no 4 or 5 star hotels are available among them (Table 5). Inexpensive hotels and motels, rental villas and hostels, budget family businesses are the most common types of accommodation on the island. Therefore, for those who are looking for an economic holiday, Ticao may be exactly the holiday opportunity they are looking for. The “Ticao Island Resort”, “Villa Teresita”, “Club de Ticao” and “Ticao Altamar” are among the top quality hotels on the island (Table 5).

Historical Catholic churches from the Spanish colonial period are one of the most popular tourist attractions of the island of Ticao. The “Immaculate Conception Parish Church” located in the Batuan town, “San Jacinto Parish Church” located in the San Jacinto town, “Parish of St. Michael the Archangel”, “San Fernando Parish Church” located in the San Fernando town are the most popular and most visited faith centers of the island Ticao (Table 6).

Table 6. Top 15 Natural and Cultural Tourism Attractions of the Ticao Island

Top 15 Natural Tourism Attractions of the Ticao Island	Top 15 Cultural Tourism Attractions of the Ticao Island
Busay Waterfall	San Fernando Parish Church
Bongsalay Natural Park	Immaculate Conception Parish Church (Batuan)
Cagpating Island	Club de Ticao Otel
Binantayan Beach	San Jacinto Water Park
Bongsanglay White Sand Beach	San Jacinto Parish Church
Mababoy Island	Matang Tubig Spring
Halea Island Nature Park	Plaza Anonuevo Park
Catandayagan Falls	Ticao Island Resor
Matabao Island	Casa Fidel - San Jacinto
Burubangkaso Rock Formation	Coolis Beach Resort
San Miguel Island	Burabod Spring
Manta Bowl Marine Protected Area	Spanish Era Cannons and San Jacinto
Altinel Beach	Old Houses in Monreal and San Jacinto
Burubangkaso Beach	Parish of St. Michael the Archangel
Paltaban Island	Looc Beach Resort Otel

(Source: Authors, 2022)

Even though it has a small area, the Ticao island harbors numerous tourist attractions and numerous tourist facilities. “Old Houses in Monreal and San Jacinto”, “Burabod Spring”, “San Jacinto Water Park”, “Spanish Era Cannons and San Jacinto”, “Matang Tubig Gold Spring” and “San Jacinto Water Park” are the most popular culture and tourism attractions the Ticao island (Table 6). The “Bongsanglay White Sand Beach”, “Burubangkaso Rock Formation”, “Busay Waterfall”, “Halea Island Nature Park”, “San Miguel Island”, “Catandayagan Falls” and “Binantayan Beach” are the most popular and most popular examples of natural tourism attractions of Ticao island (Table 6).

Major Touristic Attractions of the Ticao Island

Ticao, located between the “Ticao Strait” and the “Masbate Strait”, is one of the most frequently visited islands by the divers, as it has the richest coasts of the Philippines in terms of marine life diversity. The nature conservation areas, healing water resources, architectural monuments and historical churches from the Spanish period, interesting hydrographic and geomorphological formations, majestic waterfalls, romantic solitary beaches, sea protection zones suitable for

diving sports, touristic islets with breathtaking beauties, on the island of Ticao and nearby. They are some of the most common tourism attractions around.

The following briefly describes the main tourist attractions in and around the Ticao Island.

● **Bongsanglay Natural Park**

The “Bongsanglay Natural Park”, situated in the southeast of Ticao island, is located within the borders of the Batuan district. This ecological park, found just south of Bitos Bay and covering an area of 244 hectares, is the most important nature reserve of the Ticao island (De Los Reyes, 2017; Reboton and Candido, 2014). This nature park, situated within the borders of Masbate province, was established as a Forest Reserve on December 29, 1981 in order to protect the mangrove forests and valuable swamp areas on the Ticao island (De Los Reyes, 2017; Calumpong and Cadiz, 2012). The largest natural mangrove forests of the Bikol region and the Ticao island are located within the boundaries of “Bongsanglay Natural Park” and these interesting forests are visited by a great number of tourists every year. On May 31, 2000, this protected area was given the status of “Natural Park”. The Bongsanglay Nature Park is home to 36 mangrove species, 3 amphibian species and 11 reptile species (<https://www.7641islands.ph/explore/visiting-bongsanglay-natural-park/>). Therefore, the park area has great ecological and botanical importance. The “Bongsanglay White Sand Beach” and “Rai Son Private Beach”, which are close to the nature park, are the most popular beach areas of the region. There is neither a hotel or restaurant nor a gas station or pharmacy nor a market or residential area around the “Bongsanglay Natural Park” located in this solitary area (De Los Reyes, 2017).

● **Halea Nature Park**

The “Halea Nature Park”, one of the natural jewels of the Ticao Island, fascinates its visitors with its solitary beaches, rich underwater life and stunning natural landscapes. The Nature Park, located on the island of San Miguel, just north of Ticao and Bagababoy Islands, resembles a hidden tropical paradise with its white sandy beaches, colorful karst shapes, untouched nature, and untouched calcareous shores (Reboton and Candido, 2014). The San Miguel island, located just north of Franklin and Bagababoy Islands, is one of the most popular and interesting tourism destinations of the Ticao region with its canoe trips, fishing, hiking and scuba diving opportunities. The “Halea Nature Park” provides natural sanctuary for many sea creatures, including pristine sea waters, sea shores carved from limestone formations, corals of various colors and sizes (Yambao et al., 2001). The enthusiastic tourists who wish to watch hundreds of creatures in the clear and turquoise waters prefer snorkeling to see the rich marine ecosystem more closely. The town of Monreal, situated on the northeastern coast of Ticao Island, is the closest settlement and most convenient point of departure to set off by boat to the parkland. The “Halea Nature Park”, a hidden tropical paradise, offers an ideal ecological environment for those who wish to spend a quiet and peaceful holiday away from the restaurants and hotels, who desire to integrate with nature. The Ticao Strait, a vast body of water that separates the island of Ticao from the Luzon island, is home to the Manta Bowl, a diving site where huge manta rays feeding on plankton can be watched. Whale sharks, hammerhead sharks, and some other shark species are also common in the Ticao Strait.

● **Catandayagan Falls**

The Catandayagan waterfall, which discharges its waters directly into the ocean, is the most important tourist attraction of the Ticao island. Just like the Catandayagan waterfall, only 4-5 waterfalls in the Asian continent discharge their waters directly from the land to the sea from such a high place. Therefore, Catandayagan is both a rare geomorphological formation in nature and one of the rare examples of waterfall types. This breathtaking waterfall is located on the northwest coast of the Ticao island, within the borders of Monreal district and just north of Burubangkaso Beach. Every visitor to the Masbate Province should see this majestic waterfall. This magnificent waterfall, located very close to the "Burubangkaso Islet and Rock Formation" and "Burobangcaso Beach", is one of the most beautiful and highest waterfalls of the Philippines, which depletes its waters directly into the sea from a height of about 15 meters. The natural waterfall pool, where fresh river waters and salty sea waters meet, is ideal for both swimming and massage in the waterfall waters. Undoubtedly the Catandayagan waterfall is the most beautiful and most popular natural tourist attraction of the Ticao island.

● **Matang Tubig Gold Spring**

The "Matang Tubig Gold Spring", located in the northeastern part of the Ticao island within the borders of Monreal county, is the most famous natural water source of the island. This natural spring, located 3-4 km from the town of Montreal in the south, is a popular holiday destination for those who wish to have a picnic, swim or cool off. The stream valley, surrounded by green plants and tropical trees, acts as a unique natural decoration around the spring. The "Matang Tubig Gold Spring" is one of the coolest, most beautiful and healthiest tourism centers of the island of Ticao. The water from the stream is very clean, clear and cold, making it a natural blessing to soothe the tired bodies and souls of visitors on extremely hot and muggy days. Due to the clean and drinkable water, hundreds of local and international tourists visit the region and use the healing water source freely. Next to the stream coming from the mountains, there are waterfalls in the form of steps suitable for swimming. Therefore, both families and children love to have fun and swim in the "Parish of St. Michael the Archangel", "Classroom Points" and "Ticao Island Resort" are some of the major tourism centers that are very close to "Matang Tubig Gold Spring" and should definitely be visited.

● **Bongsanglay White Sand Beach**

The "Bongsanglay White Sand Beach", located at the southeast tip of the Ticao island, is one of the most beautiful and popular beaches on the island. This solitary beach area, located just south of the "Bongsanglay Natural Park", is notable for its quietness and solitude. There is neither a building, nor a grocery store, nor a hotel or bar, nor a settlement around it. A lonely and desolate beach, far from crowded tourist masses and noisy traffic, that even the highway cannot reach. The beach area within the borders of Batuan district fascinates the visitors with its interesting rock formations, clear turquoise sea waters and long sandy beach. The fact that there are no touristic facilities in the vicinity seems to be a great advantage in terms of preserving the naturalness of this beautiful and solitary beach. The islands of Matabao and Tatus, located just a few kilometers south of this beach area, are beautiful tourist attractions that should be visited daily with boat tours.

General Geographical Features of the Burias Island

The Burias island, situated in the Sibuyan Sea and in the Luzon Islands Group, is a medium-sized island located in the central part of the Philippine archipelago. One of the three large islands within the borders of Masbate Province, it is possible to describe Burias as a sparsely populated island with high mountains, great lakes, long streams and no cities. The surface area of Burias island is 435 km² and approximately 87000 people live on the island (<https://www.philatlas.com>; <http://psa.gov.ph/>). Burias, 51 km from Ticao island, 92 km from Sibuyan island and 190 km from Bantayan island is a long and narrow island extending in the northwest-southeast direction. San Pascual and Claveria are both the island's largest towns and the island's most important ports. There is a very old and very poor road network on the island, but most of it is unpaved and bumpy roads are only accessible by motorcycle. There is no 24-hour continuous electricity supply on the island. Generally, electricity is only available for 10-12 hours or less each day, and there is no electricity the rest of the time. Therefore, as a precaution against power cuts, each settlement has its own diesel generators to generate electricity. Frequent power and internet cuts are among the factors that negatively affect the tourism activities on the island (Alonzo, et al., 2007). There are two districts within the borders of the Burias island: Claveria and San Pascual. On the island without cities, only the towns of San Pascual and Claveria are the large settlements. All remaining settlements on the island are poor small village settlements. There are 2 towns (San Pascual and Claveria) and more than 50 village settlements on the Burias island. Claveria is located at the southeastern tip of the island, while San Pascual is located at the northwestern tip of the island. More than 80% of the villages within the island borders are located on the coast (<https://www.philatlas.com>; <http://psa.gov.ph/>). Fruit production, livestock, corn and copra production, fishing and tourism are the main livelihoods of the islanders. The Burias island is one of the least developed, least invested and poorest islands of the Philippines (Gavino-Gumba, 2010).

Tourism Potential of the Burias Island

Among the three big islands within the borders of Masbate Province, Burias is the one with the least settlements and the least tourist facilities. Burias is also the province's most sparsely populated, poorest and least developed large island in terms of economic potential. Interesting coastal formations, solitary beaches, historical churches, turquoise bays, white beaches and cute little islets are the main tourist attractions that can be visited in the Burias region. "Sombrero Island", "Fish Hook Cove Burias Island", "Tinalisayan Islet and Sandbar", "Dapa Island", "Bantigui Beach", "Animasola Island", "Pinamasingan Gulf" and "Taguilid Front Beach" are the most visited and the most popular natural tourism attractions of the Burias island (Table 7). "San Isidro Church", "San Pascual Municipal Hall", "Iglesia Ni Cristo - Lokal ng San Pascual Church", "Rizal Park", "St Pascal Baylon Church", "Water Spring Park" and "Parish of Saint Pascual Baylon Church" are the most visited and most popular cultural tourism attractions of the Burias island (Table 7). Small touristic islets such as Tinalisayan, Tanguingui, Animasola and Sombrero in the Burias region are among the most preferred touristic centers by the international tourists, both for weekend picnics or diving sports, and for swimming and relaxing by the beach (Table 7). The international tourists visiting the Burias island usually visit at least one of these charming islands, which have unearthly beautiful, clean and solitary beaches.

Table 7. Top 15 Natural and Cultural Tourism Attractions of the Burias Island

Top 15 Natural Tourism Attractions of the Burias Island	Top 15 Cultural Tourism Attractions of the Burias Island
Biton Beach	San Isidro Church
Fish Hook Cove Burias Island	Atlaza Resort
Les Coquillages White Sand Beach	San Pascual East North East Border Claveria
Ambulong Island	San Pascual West South West Border Claveria
Bantigui Beach	Parish of Saint Pascual Baylon Church
Animasola Island	Seventh-day Adventist Church San Rafael
Taguilid Front Beach	San Pascual Public Market
Pulong Dapa Island	Pahowaiian Beach Resort
Pinamasingan Gulf	San Pascual Municipal Hall
Busing Island	Virjen Island Resort
Sombrero Island	Sombrero Island Beach Resort
Tinalisayan Island	Bayanihan-Cueva Avenue
Aurora La Blanca Whitesand Beach	Casa Eduardo
San Isidro Beach	San Pascual Port
Fadeli Beach	FHM Garden Grill and Catering Osmena

(Source: Authors, 2022)

The number of both Catholic churches and other faith centers on the island of Burias is much fewer than on the Masbate island. The “Parish of Saint Pascual Baylon Church”, “Seventh-day Adventist Church San Rafael” and “San Isidro Church” are among the most curious and visited the faith centers by the local and international tourists (Table 7). There are no 4 or 5-star hotels on the Burias island, and there are no luxury accommodation facilities. Modest hostels, small family businesses and budget hotels are predominant throughout the island. The main hotels and accommodation facilities on the Burias island are; the “Pahowaiian Beach Resort”, “Les Coquillages White Sand Beach”, “Aurora La Blanca Whitesand Beach Resort”, “Casa Eduardo”, “Home Sweet Home Burias”, “Mikko's Hotel”, “Sunset View Tourist Inn”, “Atlaza Resort”, “Aping Hotel” and “Bolod San Pascual Masbate”. As is explicit, the number of accommodation facilities on the Burias island is around 10. Let us now explain this more clearly and comprehensibly by making a simple comparison. The Burias island has a surface area of 435 km² and has around 10 accommodation facilities, while Siquijor island has an area of 337 km² and serves the tourism activities with more than 160 accommodation facilities (<https://www.philatlas.com>; <http://psa.gov.ph/>). Even though the area of the Siquijor island is smaller than the Burias island and a large part of the island is covered with mountainous lands and dense forests, the fact that it has 16 times more accommodation facilities than the Burias island demonstrates that the tourism activities in Burias are still in their infancy.

Major Touristic Attractions of Burias Island

Among the 3 big islands in the Masbate Province, Burias is the island with the least population, the least number of districts and the least number of hotels and accommodation facilities. Therefore, when compared to the islands of Ticao and Masbate, it is clear that Burias is the island with the least number of tourism centers and the least developed tourism activities. Small cute tropical islets, wide bays and peninsulas, beaches covered with white sandy beaches, breathtaking coastal formations and architectural works from the Spanish colonial period are among the most common tourist attractions on the Burias island. The following explicates the main tourism attractions on the Burias island and its surroundings.

● Animasola Island

With its white beaches and steep cliffs, the Animasola island is one of the must-see touristic centers in the Burias region. This small islet, located just northeast of Burias island, fascinates the tourists with its sea erosion surfaces, steep cliffs, high stony shores and interesting rock shapes. There are daily tours to the Animasola island by chartered boat from the San Pascual town of the Burias island. There is neither a settlement nor a hotel or restaurant on the island, nor a grocery store or government office. However, the Philippines' most beautiful examples of cliffs, the most striking wave erosion patterns and the most interesting sea cliffs are undoubtedly situated in Animasola. Briefly, even though the Animasola Island is nothing more than a huge natural rock museum carved by the ocean waves, it is worthwhile to visit the island for its breathtaking natural beauty.

● Les Coquillages White Sand Beach

The “Les Coquillages White Sand Beach”, found on the southwest coast of the Burias Island, is one of the most beautiful and popular beaches of the island. This famous beach, situated on the shores of the Sibuyan Sea, within the borders of Barangay San Isidro, in Claveria county, is a secluded, clean, quiet and tranquil resort away from the big hotels and crowded tourist masses. The “Les Coquillages White Sand Beach Resort” adjacent to the beach and “Pahowaiian Beach Resort” located 1-2 kilometers south of the beach area are the only accommodation options in the region. The “Les Coquillages White Sand Beach Resort Hotel” that offers 5 cottages on the shores of the Sibuyan Sea, tries to meet the needs of tourists with limited means. In fact, both the entire beach and this small hotel are run by one family. The long white beaches, clear and clean sea waters, dense rain forests, desolate coasts that have not yet been exposed to concrete and construction are the biggest touristic advantages of the beach. The lack of transportation connections and infrastructure and the almost non-existence of touristic facilities such as restaurants, bars and hotels are the main reasons why the beach area is visited by very few international tourists.

● Tinalisayan Island

Tinalisayan, found in the northwest of Burias island, is located a few kilometers northwest of Busing Island. A miracle of nature with its clear ocean waters and hidden white beaches, Tinalisayan is one of the most impressive and beautiful islands of the Burias region. The long coastal pole, consisting of white sand dunes and nestled meters into the sea, has become the touristic symbol of this island and has inspired hundreds of postcards. The shore pole, which emerges during low tides and consists of white dunes, offers the appearance of a swimming

platform in the middle of the sea and fascinates the visitors. For those looking for romantic holidays, snorkeling and quiet beaches, this mysterious and quaint island is a perfect opportunity. There are no hotels, bars, restaurants, markets or government offices on the island. Furthermore, since there are no accommodation facilities on this desolate island, it is recommended that visitors bring their own food supplies and their own tents.

Conclusion

Masbate, which has failed to attract the attention of the Manila governments, the provincial administrators and major tourism investors until the 21st century, can be described as a poor and sparsely populated province with flat and desolate lands. It is explicit that the basic economic sectors such as trade, industry, construction and transportation within the borders of the province have not highly developed in the 21st century. However, it is common knowledge that this rapidly developing, prospering and developing province in the last quarter century has a huge tourism potential. Since Masbate is a newly developing and prospering province in the 21st century, it is natural for the tourism activities to develop in the islands within the borders of the province. Therefore, it is hoped that the economic development will accelerate and the international tourism revenues will increase with the economic investments to be made in the islands within the borders of the province in the coming years. Therefore, the tourism sector in Masbate is regarded as the "economic savior of the province".

The tranquil and peaceful tropical islands, desolate white sandy beaches, pristine untouched ecosystems and breathtaking natural beauties are the Masbate province's greatest tourism wealth. Fascinating coral reefs and rich marine life diversity have made Masbate one of the Philippines' top diving destinations. The festivals organized in different settlements of the province every year attract the attention of both domestic and international tourists and promote the touristic activity. Therefore, marine tourism, adrenaline tourism, festival tourism, ecotourism, adventure tourism, rural tourism and sports tourism are the most common types of tourism in the islands within the borders of the province. As we rush towards the middle of the 21st century, Masbate, with all its tropical innocence, all its unique tourism resources and all its natural beauty, is waiting to be discovered by the international tourists. The following summarizes and examines the main tourism advantages of the Masbate province.

The major tourism advantages of the Masbate province can be summarized as follows:

- The lack of production activities and large industrial facilities that will pollute the environment within the borders of the province can be considered as a great chance for the development of ecological tourism. The Masbate province, which does not have large factories and commercial centers, large thermal power plants and crowded metropolitan cities, will continue to be preferred as a tourism destination as long as it preserves its natural resources and ecosystems. In conclusion, the untouched natural elements, uncontaminated land and sea ecosystems, untouched natural beauties that are not available anywhere else are the most important tourism wealth of the province.

- The islands and coasts within the borders of Masbate province have very appropriate geographical, ecological and climatic features for diving, snorkeling and surfing. The quiet

beaches lined with white beaches, turquoise coves and bays, interesting coastal formations and wave erosion patterns, and colorful coral reefs that are very popular with the divers are the main natural tourism attractions of the province.

● There are around 20 islands within the borders of Masbate province, but about 10 of them can be described as "touristic islets" with intense tourism activities. Since daily boat tours are organized to these tropical islands, they are of great importance in terms of sea tourism and various recreational activities, as well as water and diving sports. In fact, the islets such as Tinalisayan, Busing, San Miguel, Magcaraguit, Sombrero, Animasola and Dapa have breathtaking natural beauties and interesting tourism attractions that are unique not only in the Philippines but also in the entire Asian continent. These small uninhabited tropical islets, therefore, are both the most famous attractions and the greatest touristic wealth of the Masbate province.

● Masbate is a calm, peaceful and safe province where every international tourist can have a holiday with peace of mind, away from the terrorist incidents. The non-existence of security, traffic and terrorism problems in all the islands within the provincial borders, as well as the non-existence of social problems such as extortion, murder, attack and theft are important and positive features for the international tourists coming to the islands.

● The fact that most of the hotels, restaurants, hostels, bars and other touristic facilities within the borders of Masbate province offer cheap services and economical prices is regarded as a positive feature for the tourists. The low-income tourists who do not wish to spend their holidays in expensive accommodation on the neighboring island of Luzon can sometimes choose one of the islands within the provincial borders as a new destination. Therefore, it is possible to claim that the Masbate province has appropriate opportunities for youth tourism, senior tourism as well as family tourism.

● Within the borders of the Masbate province, there are interesting ecosystems and stunning natural beauties not available anywhere else in the Philippines and a significant part of them are found within the borders of nature reserves. Therefore, the nature reserves such as "Halea Nature Park", "Bongsanglay Natural Park", "Manta Bowl Marine Protected Area", "Buntod Sandbar and Reef Marine Sanctuary" and "Chico Island Wildlife Sanctuary" are situated in both terrestrial and marine geographical spaces. It has a great function and significance in terms of the development of tourism activities in the province (Pagunutalan et al., 2004).

● Even though the Masbate province, with its rich natural resources and unique tourism attractions, has already proven itself to be a unique geographical location, it has not been able to promote it to the world and prove it in the global tourism markets. Even though diversity and originality are the biggest tourism trump cards of the islands in this province, it is explicit that the Philippine tourism authorities have not been able to promote this to both the tourism experts and the international tourism markets. One of the main reasons for doing this study and writing this article is to successfully carry out the "global tourism promotion" and "scientific analysis initiative" of this little-known province.

Conflict of interest

The authors confirm that there was no conflict of interest during the study.

Authors' contributions

In this article the contribution of each author, in the work on the article.

– significant contribution to the design of the work, collection, analysis or interpretation of the results of the work of **Emin Atasoy**;

– writing the text and its content, approval of the final version of the article for publication by **Hakan Önal**.

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Дамушы жаңа туристік бағыт:

**Масбате провинциясының географиялық ресурстары мен туристік әлеуеті
(Филиппин Республикасы)**

Аңдатпа. Филиппин архипелагының орталық бөлігінде орналасқан Сибуян, Висаян және Самар теңіздерімен қоршалған Масбате провинциясына 3 үлкен арал (Масбате, Тикао және Буриас) және көптеген шағын аралдар кіреді. Масбате провинциясының құрамындағы барлық аралдар физикалық географиясы орналасуы бойынша Лусон аралдары тобына кіреді; саяси-әкімшілік географиясы жағынан да олар «Бикөл әкімшілік аймағының» ішінде орналасқан.

Әкімшілік құрылымы бойынша Масбате провинциясында 20 аудан, 1 қала (Масбате) және 550 барангай бар. Масбате провинциясының бай табиғи ресурстары мен кен орындары, ауыл шаруашылығы және балық аулау әлеуеті жоғары болғанына қарамастан, халықаралық туризмде әлі де айтарлықтай табысқа жете алмады. Бұл зерттеуде Масбате провинциясының ең үлкен аралдары болып табылатын Масбате, Тикао және Буриас зерттеліп, талданып, олардың географиялық ерекшеліктері, туристік әлеуеті мен аралдардың туристік тартымдылығы да қарастырылған. Мақалада Масбате провинциясындағы негізгі орналастыру орындары, қорықтары, аралдары мен жағажайлары, табиғи және мәдени туристік көрікті жерлері, сондай-ақ, Масбате провинциясындағы туризмнің артықшылықтары мен кемшіліктері талқыланған. Зерттеудің негізгі мақсаты – оқырмандарды шетелдік туристер арасында аса танымалдығы жоқ Масбате провинциясының туристік ресурстарымен, мәдени байлығымен және табиғи сұлулығымен таныстыру, сондай-ақ Масбате провинциясының атын әлемдік туристік нарықта танымал ету және қызығушылық танытатын туристер үшін жаңа демалыс нұсқаларын ұсыну.

Түйін сөздер: Масбате провинциясы, туристік орындар, Филиппин Республикасы, халықаралық туризм, Филиппин архипелагы.

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**Развивающееся новое туристическое направление:
географические ресурсы и туристический потенциал провинции Масбате
(Республика Филиппины)**

Аннотация. Провинция Масбате, окруженная морями Сибуян, Висаян и Самар, расположенная в центральной части Филиппинского архипелага, включает в себя 3 крупных острова (Масбате, Тикао и Буриас) и множество мелких островов. Все острова в пределах провинции Масбате являются лишь частью группы островов Лусон с точки зрения физической географии; также с точки зрения политической и административной географии они расположены в пределах «административного региона Бикол». С точки зрения административного устройства в провинции Масбате насчитывается 20 округов, 1 город (Масбате) и 550 барангаев. Несмотря на то, что провинция Масбате обладает богатыми природными ресурсами и шахтами, большим сельскохозяйственным и рыболовецким потенциалом, ей пока не удалось добиться желаемого успеха в международном туризме. В этом исследовании Масбате, Тикао и Буриас, которые являются крупнейшими островами провинции Масбате, изучаются и анализируются по отдельности, а также учитываются их географические особенности, туристический потенциал и туристическая привлекательность этих островов. В этой статье рассматриваются основные объекты размещения, основные природные заповедники, острова и пляжи в пределах провинции Масбате, а также природные и культурные туристические достопримечательности; кроме того, рассматриваются преимущества и недостатки туризма в провинции Масбате. Основная цель исследования - познакомить читателей с туристическими ресурсами, культурными богатствами

и природными красотами провинции Масбате, которая на самом деле не очень популярна среди иностранных туристов, а также популяризировать название провинции Масбате на мировых туристических рынках и предложить новые варианты отдыха для любознательных туристов.

Ключевые слова: провинция Масбате, туристические достопримечательности, Республика Филиппины, международный туризм, Филиппинский архипелаг.

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Обзорная статья

Обзор мониторинга лесов в Казахстане на основе наблюдения за Землей

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Аннотация. Лесной фонд Казахстана занимает 5% территории страны, а их площадь составляет 13,6 млн га. Леса в природе выполняют разнообразные функции для природы и общества, а также играют важную роль в выравнивании климата. Изменение климата, проявляющееся в повышении температуры и нынешних экстремальных погодных условиях, оказывает негативное воздействие на здоровье и развитие лесов. За последние пять лет сильная засуха и жара, а также последующее массовое размножение вредителей серьезно повлияли на леса страны. Учитывая нынешние масштабы ущерба лесам и возникающие долгосрочные последствия, усилия по сохранению лесов в Казахстане, а также их разнообразия и продуктивности является незаменимой задачей правительства. На сегодняшний момент активно проводятся лесовосстановительные работы, работы по охране и рациональному использованию лесных ресурсов в Республике Казахстан. Количественные данные являются одним из средств принятия обоснованных решений для обеспечения мониторинга лесов и улучшения мониторинга ущерба лесам. В дополнение к существующим системам мониторинга лесов, таким, как инвентаризация лесов, обследование состояния кроны и инвентаризация лесных почв, систематические исследования состояния и уязвимости лесов в национальном масштабе могут быть расширены с помощью спутниковой системы наблюдения. наблюдение за землей. В этом обзоре мы проанализировали и классифицировали все исследования, опубликованные за последние 20 лет и посвященные дистанционному зондированию лесов в Казахстане.

Ключевые слова: дистанционное зондирование, наблюдение Земли, лесной фонд, мониторинг леса, деградация леса, Казахстан, обзор.

Введение

Мировой лесной фонд и леса предоставляют чрезвычайно ценные экосистемные услуги и вносят огромный вклад в благосостояние человека. Их вклад можно сгруппировать в обеспечивающие, вспомогательные, регулирующие и культурные услуги [1, 2]. Лесной фонд обеспечивает сырье, такое, как древесина или растительное волокно (строительная древесина, мебельная древесина, бумага, уголь и т.д.), прямые и косвенные продукты питания (травы, фрукты, орехи, мед, грибы, дичь, насекомые и т. д.) и химические вещества и лекарственные средства (скипидар, масла, резинат и т.п.), а также зачастую предоставление доступа к источникам чистой воды. Леса служат средой обитания для флоры и фауны, являются домом для огромного биоразнообразия и способствуют почвообразованию и круговороту питательных веществ. Кроме того, леса способствуют защите земель от эрозии, включают фильтрацию воды и воздуха, удержание воды, а также борьбу с наводнениями и засухой. Держат в балансе изменения климата за счет фиксации углерода в растениях и почвах. Культурный вклад: включают отдых (например, прогулки, походы, езда на велосипеде, верховая езда, катание на беговых лыжах, охота и т. д.), эстетику, экологическое образование и духовные услуги [3].

Казахстан относится к малолесистым странам. Согласно данным Комитета лесного хозяйства и животного мира Министерства экологии, геологии и природных ресурсов, по состоянию на 1 января 2022 г. леса занимают 5% территории страны, а их площадь составляет 13,6 млн га. Почти половина из них приходится на саксаул. В целом благодаря усилиям, направленным за охрану лесов, их восстановление и рациональное использование за последние годы в Казахстане наблюдается тенденция к увеличению лесных массивов.

Большая часть государственного лесного фонда – 74,9 % находится в ведении акиматов областей, в ведении Комитета находится 24,4 %. Площадь государственных лесовладельцев, подчинённых Комитету, составляет 7450,9 тыс. га, из них 7335,9 тыс. га – особо охраняемые природные территории со статусом юридического лица, к которым относятся: 10 государственных природных заповедников; 14 государственных национальных природных парков; 7 государственных природных резерватов.

Наибольший вред лесам наносят лесные пожары, которые могут свести на нет действенность всех, проектируемых лесоустройством и проводимых лесными учреждениями, мероприятий. В 2019 году на территории государственного лесного фонда произошло 628 пожаров, в сравнении с прошлым годом зарегистрирован их рост на 75,4% (2018 г.–358). Материальный ущерб также увеличился в 2,6 раза (2018 г. – 209 млн. 619 тыс. тенге, 2019 г. – 563 млн 509 тыс. тенге), при этом лесная площадь, пройденная пожарами, снизилась в 2,2 раза и составила 73 тыс. 515 га (2018г. – 162 тыс. 611 га) [4, 5, 6].

Особо следует отметить, что разработка научно обоснованной системы по мониторингу и сохранению лесов страны, мероприятий по уменьшению негативных последствий и увеличения продуктивности лесов может быть выполнена на основе использования современных технологий и методов.

Целями данного обзора мониторинга лесов на основе ДЗЗ данных в Казахстане являются:

- представить всестороннее, актуальное и обоснованное на фактах введение о лесах в стране и текущие проблемы;
- представить результаты углубленного обзора и анализа всех исследований, основанных на ДЗЗ, посвященных лесам в Казахстане.

Обзор литературы

За последние пять лет изучение Земли с использованием спутников вступило в новую эру. Принимая во внимание, что в течение многих лет непрерывный, ежедневный или почти ежедневный мониторинг определенной области интересов на нашей Земле мог осуществляться только на основе данных с низким и средним разрешением спутниковых датчиков, таких, как AVHRR (пространственное разрешение от 1 км до 4 км, поскольку в начале 1980-х годов), MODIS (разрешение от 1 км до 250 м с 1999 г.) или MERIS (300 м, доступно только в 2002–2012 гг.), датчики с более высоким разрешением, такие, как бортовые спутники Landsat (пространственное разрешение 30 м), предоставляли только возможность двухнедельного наблюдения, благодаря частоте повторения 16 дней. Запуск Европейским космическим агентством (ESA) европейского спутника данных Sentinel в 2014 году привел к смене парадигмы в отношении возможностей мониторинга на основе ДЗЗ. Основанная на сочетании мультиспектральных датчиков более высокого разрешения, таких, как TM, ETM+ и OLI, на Landsat-5, 7 8 и 9 (30 м), и особенно европейские спутники Sentinel, такие, как Sentinel-2 A и B (разрешение от 10 до 20 м), Sentinel-3 (разрешение 300 м) и датчики с синтезированной апертурой (SAR), такие, как Sentinel-1 A и B (пространственное разрешение от 10 до 20 м).), теперь можно наблюдать за каждым местом на Земле с высоким разрешением почти ежедневно. Помимо этих спутников, существуют также датчики с более высоким разрешением, такие, как Ikonos, Quickbird, Worldview, или микроспутники, подобные тем, которые контролируются корпорацией Planet, теперь можно наблюдать за каждым местом на Земле с высоким разрешением почти ежедневно [7, 8]. Хотя данные SAR (радар с синтезированной апертурой) не зависят от погоды, облачность может быть ограничивающим фактором для пассивных систем дистанционного зондирования. Однако с таким парком датчиков даже в частично облачных регионах средних широт, теперь возможно генерировать информационные продукты с высоким пространственным разрешением и высоким временным разрешением и оптимально с интервалом от недели до месяца.

Наборы данных с более высоким пространственным разрешением и охватом территории позволяют получать информационные продукты о динамике и распределении лесного покрова в масштабах всей страны, а также получать подробные информационные продукты о потере лесов, видовом составе и его изменениях, нарушениях лесов из-за засух, пожары, ураганы и эпидемии, а также восстановление и возобновление роста лесов.

На европейском уровне в течение последнего десятилетия различными способами поощрялось использование спутниковой информации о лесах. Тематическая платформа

лесного хозяйства (Forestry TEP) была разработана в рамках проекта, заключенного по контракту с Европейским космическим агентством (ESA), чтобы обеспечить более эффективное использование данных Copernicus и других данных ДЗЗ в поддержку мониторинга лесных экосистем и устойчивого лесопользования [9].

Система мониторинга земель Copernicus также содержит слой лесного хозяйства высокого разрешения с тремя типами продукции, доступной за 2012 и 2019 годы: плотность древесного покрова, доминирующий тип листвы (лиственные, хвойные и т.д.) и продукт типа леса, соответствующий определению леса Продовольственная и сельскохозяйственная организация (ФАО) [10]. В качестве основного источника входных данных для продуктов использовались данные Sentinel-2, а также данные Landsat 8 в основном [11].

Однако изучение исследований на основе ДЗЗ и геоинформационных продуктов, доступных в Казахстане, показывает, что преобладают местные и региональные исследования и информационные продукты на основе ДЗЗ, и что количественная информация в региональном и даже национальном масштабе генерируется редко. Научно-исследовательские институты по-прежнему используют (если вообще используют) информацию о лесах, полученную с помощью дистанционного зондирования, скорее в экспериментальных целях и не содействуют оперативному мониторингу. Однако здесь кроется исключительный потенциал для проведения своевременных, повторяемых и крупномасштабных оценок, поддерживающих традиционно проводимые оценки на месте.

Методология

Для этого обзора мы собрали все доступные исследовательские публикации по темам, связанные с лесами, исследования с помощью дистанционного зондирования в Казахстане. Поиск литературы проводился на основе библиографической базы данных платформы Web of Science без ограничений по дате публикации, ResearchGate и Google Scholar. Мы рассматривали только научные статьи, опубликованные в рецензируемых журналах. При поиске литературы мы использовали следующие ключевые слова: лес ИЛИ лесной фонд И дистанционное зондирование ИЛИ наблюдение за землей И Казахстан. И нами были выявлены около 122 исследовательских публикаций, посвященных лесам и лесному фонду Казахстана.

Результаты и обсуждение

По данным Национального доклада о состоянии окружающей среды и об использовании природных ресурсов, леса в Казахстане располагаются крайне неравномерно. Типы лесной растительности обуславливаются разнообразием природных зон. В пустынной зоне произрастают саксауловые леса. Основная часть горных лесов представлена темнохвойными насаждениями Алтая, Джунгарского и Заилийского Алатау. В равнинной части степной и лесостепной зон произрастают березово-осиновые колочные леса, островные сосновые боры, ленточные боры Прииртышья [12].



Рисунок 2. Статистика по пожарам лесов по Казахстану [13]

Причинами возникновения лесных пожаров являются природные (неконтролируемые сельскохозяйственные палы) и антропогенные факторы («сухие» грозы). Кроме того, серьезной угрозой лесным ресурсам является периодическое распространение вредителей и болезней леса.

В рамках Парижского соглашения, согласно которому Казахстан взял на себя обязательства по сокращению выбросов парниковых газов до 2030 года на 15%, путем сохранения существующих лесов и создания новых лесных насаждений. В рамках этой инициативы была проведена инвентаризация неучтенных горных лесов Восточно-Казахстанской области; с использованием космических и аэроснимков были определены их границы, породный состав и состояние. В результате этих исследований было выявлено более 67 тыс. га неучтенных горных лесов, которые за последние 30 лет поглотили углерода около 6 млн тонн CO₂-эквивалента.

Также при поддержке Глобального экологического фонда (ГЭФ) ПРООН реализует и другие инициативы с целью сохранения лесов. В рамках партнерства ПРООН-ГЭФ в Казахстане усилия сосредоточены на предотвращении обезлесения и деградации лесов, защиты их от пожаров путем внедрения практики использования современных технологий для мониторинга и оценки рисков возникновения природных и антропогенных угроз.

За последние несколько лет предпринимаемые меры, направленные на защиту лесов Казахстана, уже принесли существенные результаты, поэтому в дальнейших перспективах необходимо уделить особое внимание внедрению новых технологий в долгосрочные стратегии с целью защиты и ускорения процесса улучшения благосостояния лесных экосистем. Благодаря устойчивому управлению, поддержанию их здоровой среды и созданию условий для их естественного возобновляемого процесса, леса продолжают служить важнейшей артерией жизнедеятельности людей и планеты.

С 2018 года Национальный оператор космической системы дистанционного зондирования Земли (АО «НК «Казахстан Гарыш Сапары») приступил к работам по изучению геоинформационных систем для проведения космического мониторинга и лесопользования мира. Площадь занимает менее 5% от общей площади территории.

Актуальные вопросы мониторинга лесных ресурсов: изменение площади лесов, количества рубок, количества гарей, прогноз пожарной опасности лесного покрова и т.д. По результатам космического мониторинга и по данным дистанционного зондирования Земли, подтвержденным также полевыми исследованиями на ключевых участках, впервые в истории расшифрованы все леса Казахстана, созданы цифровые карты лесов Казахстана с подробной атрибутивной информацией вплоть до видового состава лесов, возраста и иная конкретная информация предоставлена ГП «Казахское лесоуправление», выявлено несколько тысяч рубок, в том числе незаконных, также расшифрованы гари и выгружены все данные на промышленный геопортал с актуальной атрибутивной информацией.

На сегодняшний момент на основе данных дистанционного зондирования Земли проводится работа по космическому мониторингу лесных ресурсов Казахстана и разработаны геосервисы для Комитета лесного хозяйства и животного мира Министерства сельского хозяйства Республики Казахстан. Данные геосервиса представлены на отраслевом геопортале и позволяют Комитету лесного хозяйства и животного мира Министерства экологии и природных ресурсов Республики Казахстан в оперативном режиме получать информацию для эффективной и оперативной работы по управлению, контролю и мониторингу за Государственным лесным фондом Республики Казахстан.

В данный момент существует несколько исследований, связанных с мониторингом и исследованиями лесов в Казахстане с использованием дистанционного зондирования. Однако необходимо учитывать, что с течением времени исследования и технологии могли измениться. Ниже приведены некоторые темы и методы исследований лесов, проведенных с использованием дистанционного зондирования:

1-Картографирование лесных ресурсов:

Использование спутниковых данных для создания карт, которые отображают распределение и состояние лесных ресурсов в Казахстане. Это может включать оценку площади лесов, видового состава и состояния древостоев.

2-Мониторинг лесных пожаров:

Использование спутниковых данных для отслеживания и мониторинга возгораний и лесных пожаров в реальном времени. Это важно для оперативного реагирования на чрезвычайные ситуации.

3-Оценка состояния лесов и деградации:

Использование дистанционного зондирования для оценки состояния лесов, включая деградацию почвы, уровень древесного покрова и потерю лесного покрытия.

4-Изучение биоразнообразия:

Применение данных спутникового зондирования для анализа биоразнообразия в лесах, включая распределение видов и местообитаний.

5-Мониторинг общей площади лесов:

Использование спутниковых данных для оценки изменений в общей площади лесов в течение определенного времени.

6-Оценка антропогенного воздействия на леса:

Использование дистанционного зондирования для оценки влияния человеческой деятельности на лесные экосистемы, включая вырубку деревьев, изменение земельного использования и строительство.

Для получения актуальной и подробной информации о современных исследованиях лесов в Казахстане на основе дистанционного зондирования рекомендуется обратиться к последним публикациям в специализированных научных журналах, а также связаться с учеными, работающими в данной области в Казахстане.

Как уже упоминалось, в ходе исследования было выявлено около 122 исследовательских публикаций, посвященных лесам и лесному фонду Казахстана. И только 21 исследование проводилось с использованием ДЗЗ данных и методов. Большинство исследований было опубликовано в течение последнего десятилетия. Рост числа связан с увеличением доступности данных дистанционного зондирования (например, первый спутник Sentinel в 2014 году). Этот факт также отражен в представлении категории журналов с увеличением количества исследований, опубликованных в журналах, посвященных дистанционному зондированию, в последние годы.

Поскольку мы рассматриваем исследования только в Казахстане, большинство первых авторов – это, в основном, ученые, работающие в казахстанских университетах или исследовательских институтах. Исследования, в основном, проводились в университетах, причем большинство авторов имели опыт работы в области дистанционного зондирования.

Среди них особенно можно выделить следующие публикации, связанные с лесным мониторингом в Казахстане с использованием дистанционного зондирования (ДЗЗ):

– *"Assessment of Forest Resources in Kazakhstan using Remote Sensing Data"* (Оценка лесных ресурсов в Казахстане с использованием данных дистанционного зондирования) [14].

Авторы: А. Otarov, А. Mamutov, А. Erzhanov, и др.

Описание: Исследование по оценке лесных ресурсов в Казахстане с использованием различных методов дистанционного зондирования. В работе оценивается состояние лесов, их распределение и динамика изменений с течением времени.

– *"Monitoring and Assessment of Forest Cover Changes in Kazakhstan"* (Мониторинг и оценка изменений лесного покрова в Казахстане) [15].

Авторы: М. Joldasova, А. Kabikenov, К. Dosmukhamedov и др.

Описание: Исследование по мониторингу и оценке изменений лесного покрова в Казахстане с помощью анализа спутниковых данных. Основное внимание уделяется изменениям в лесном покрове и их влиянию на экосистемы.

– *"Developing the forest fire danger index for the country kazakhstan by using geospatial techniques"* (Разработка индекса пожарной опасности лесов для страны Казахстан с использованием геопространственных методов) [16].

Авторы: S. Babu, G. Kabdulova, G. Kabzhanova.

Описание: Исследование по применению данных дистанционного зондирования для оценки пожароопасности территории, примененный статический индекс вероятности лесных пожаров был разработан с использованием продукта SRTM DEM и MODIS TERRA и продукта типа земельного покрова AQUA (MCD12Q1) для реагирования на пожары и управления ими.

– "Satellite remote sensing for monitoring of the forest resources of Kazakhstan" (Спутниковое дистанционное зондирование для мониторинга лесных ресурсов Казахстана) [17].

Авторы: G Kabdulova, G Kabzhanova, K Baktybekov, и др.

Описание: В статье представлены результаты использования данных ДЗЗ и геоинформационных технологий при оценке лесного покрова Казахстана, законности рубок, оценке площадей гарей и т.д.

Что касается пространственного охвата, большинство исследований было сосредоточено на местном и региональном масштабе. Только шесть из 21 научной работы охватывали лесную площадь Казахстана в целом.

Восемь исследований касались общей площади лесов земель одной или двух областей или конкретного лесного массива. Чаще всего охватывался лесной фонд Восточного Казахстана с ее лесной площадью. Мы нашли около 5 документов о возможностях применении ДЗЗ методов и данных для мониторинга лесных ресурсов.

Заключение

Что касается обзора, мы должны отметить, что некоторые статьи, возможно, не были включены в обзор и потенциально могли содержать дополнительную информацию. Поскольку наш географический фокус сосредоточен только на статьях, имеющих в названных базах, мы могли упустить некоторую информацию, представленную в других источниках. Однако в таком масштабе мы не ожидаем найти много дополнительных деталей или более точных результатов по сравнению с широко используемыми базами. Исследования, охватывающие Центральную Азию, не предоставят углубленных биогеофизических параметров, позволяющих дифференцировать продукты по отношению к стране. Кроме того, анализировались только исследования, опубликованные в рецензируемых журналах, что, в свою очередь, объясняет небольшое количество публикаций. Административный сектор в основном публикует результаты в официальных отчетах, которые не рассматриваются в нашем обзоре, как это обычно бывает со многими другими обзорами научной литературы.

Текущая научная литература по исследованиям леса с помощью дистанционного зондирования в Казахстане предполагает устойчивый рост использования данных, полученных с помощью ДЗЗ, для различных анализов, связанных с лесами. Весьма вероятно, что это связано с увеличением количества и пригодности (с точки зрения пространственного, временного и спектрального разрешения) доступных датчиков и данных ДЗ. Более того, становится все проще получить свободный доступ к данным ДЗ. Грамотность обработки данных также растет.

Недавнее увеличение доступности источников данных ДЗ с высоким пространственным и временным разрешением соответствует наблюдаемому увеличению количества многовременных анализов. С увеличением объема данных возникают новые проблемы с точки зрения хранения и обработки таких данных. Доступен ряд технических решений, многие из которых являются программным обеспечением с открытым исходным кодом, облегчающим анализ больших объемов данных ДЗ. Есть Службы доступа к данным и

информации ЕС Copernicus или Система доступа, обработки и анализа данных наблюдения Земли для мониторинга земель (SEPAL). Ожидается, что этот сдвиг парадигмы в анализе данных ДЗ в сторону анализа временных рядов с высоким разрешением из нескольких источников также изменит применение ДЗ в лесном секторе страны в ближайшие годы. Хотелось бы чтобы институты и университеты при проведении исследований также предоставляли готовые данные в открытом доступе.

Более крупные исследовательские институты и организации часто имеют собственный опыт и вычислительную инфраструктуру, они предоставляют в основном государственным органам или по официальному запросу.

В нашем анализе выделяется тот факт, что на национальном уровне проводится очень мало исследований. Хотя новые типы датчиков и улучшенная доступность данных (бесплатность, достаточно высокое пространственное разрешение, а также частый и полный охват) позволяют осуществлять непрерывный мониторинг всех лесов в Казахстане, представляется, что потенциал ДЗ для мониторинга еще не полностью использован. Объяснением этому может служить довольно сложная институциональная среда в лесном секторе, поскольку фактическое управление лесами обычно осуществляется на региональном или государственном уровне. Другой причиной может быть тот факт, что необходимая инфраструктура обработки или знания о ней для анализа большого количества данных лишь недавно были созданы в научно-исследовательских институтах, университетах и органах государственной власти. Кроме того, все еще существуют многочисленные ограничения информации, полученной с помощью ДЗ, по сравнению с данными, полученными на месте. Когда дело доходит до идентификации определенных видов деревьев, ДЗЗ может либо вообще не предоставить эту информацию, либо не с такой точностью, как данные полевых исследований. С другой стороны, полное и регулярное картирование лесного покрова (а также других параметров, таких, как типы лесов, оценка биомассы, нарушения лесов и т. д.) уже можно было бы выполнить с достаточной степенью точности. Затем это можно было бы дополнить дальнейшими детальными исследованиями (на основе данных наземного зондирования с более высоким разрешением или инвентаризаций на месте).

В Америке, например, дистанционное зондирование является важным источником информации для поддержки управления лесами [18]. Несмотря на то, что выезды на места утомительны, трудоемки и дорогостоящи, они составляют основу инвентаризации лесов, особенно в таких крупных странах, как Соединенные Штаты. Поэтому дистанционное зондирование, особенно с использованием временных рядов свободно доступных спутниковых данных, играет решающую роль в дополнении наземных исследований в этих странах.

Научная деятельность, связанная с лесами, в Казахстане пока еще не тесно связана и не интегрирована в программы инвентаризации лесов. Однако существует также достаточно доказательств того, что дистанционное зондирование способно предоставлять оперативную информацию о лесах на национальном и региональном уровне [5].

Более того, мы ожидаем, что новые возможности откроются, когда в будущем архивы спутниковых данных более высокого разрешения с датчиков, таких, как Ikonos, Quickbird, Worldview или Planet, станут бесплатными.

В целом, за последние несколько лет интерес к использованию дистанционного зондирования для мониторинга лесов возрос. Однако по-прежнему не хватает общенациональных исследований и оценок параметров лесов. Чтобы обеспечить лесоправлению и властям информацию от ДЗЗ, необходимо продолжить разработку надежных методов мониторинга и внедрить их на региональном и государственном уровне.

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Жерді бақылау негізінде Қазақстандағы орман мониторингіне шолу

Андатпа. Қазақстандағы орман қоры ел аумағының 5%-ын алып жатыр, ал олардың ауданы 13,6 млн га. Табиғаттағы ормандар табиғат пен қоғам үшін сан алуан қызмет атқарады, сонымен қатар климатты теңестіруде маңызды рөл ойнайды. Температураның жоғарылауы мен қазіргі экстремалды ауа-райы жағдайында көрінетін климаттың өзгеруі ормандардың денсаулығы мен дамуына теріс әсер етуде. Соңғы бес жылда қатты қуаңшылық пен жоғарғы ыстық, одан кейін пайда болған зиянкестер елдегі орман алқаптарына айтарлықтай зиянын тигізеді. Орманға келтірілген залалдың қазіргі ауқымын және одан туындайтын ұзақ мерзімді салдарды ескере отырып, Қазақстан ормандарын, сондай-ақ олардың алуан түрлілігі мен өнімділігін сақтау жөніндегі күш-жігер Үкіметтің таптырмас міндеті болып табылады. Бүгінгі таңда Қазақстан Республикасында ормандарды молықтыру жұмыстары, орман қорын қорғау және тиімді пайдалану жұмыстары белсенді жүргізілуде. Сандық деректер орман мониторингін қолдау және орманның зақымдалуын бақылауды жақсарту үшін негізделген шешімдерді қабылдаудың бір құралы болып табылады. Қолданыстағы орман мониторингі жүйелеріне қосымша, мысалы,

орманды түгендеу, олардың денсаулығын зерттеу және орман топырағын түгендеу, ұлттық ауқымдағы ормандардың денсаулығы мен осалдығын жүйелі түрде зерттеуді спутниктік бақылау жүйелері арқылы жақсартуға болады. Бұл шолуда біз Қазақстандағы ормандарды қашықтықтан зондтау бойынша соңғы 20 жыл ішінде жарияланған барлық зерттеулерді талдауға тырыстық.

Түйін сөздер: арақашықтықтан зондтау, Жерді бақылау, орман қоры, орман мониторингі, орманның деградациясы, Қазақстан, шолу

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An overview of forest monitoring in Kazakhstan based on Earth observation

Abstract. The forest fund in Kazakhstan occupies 5% of the country's territory, and its area is 13.6 million hectares. Forests in their natural state fulfil a various function for both natural world and society, and also play an important role in balancing the climate. Climate change, manifested in the increase in temperature and the current extreme weather conditions, has a negative impact on the health and development of forests. Over the past five years, the country has experienced a series of extreme weather events, including prolonged droughts and heatwaves, which have resulted in significant damage to its forests. Considering the current scale of forest damage and the resulting long-term consequences, efforts to preserve forests in Kazakhstan, as well as their diversity and productivity, is an indispensable task of the government. Today, the reforestation, protection, and rational use of forest resources in the Republic of Kazakhstan have been actively pursued. Quantitative data is one of the means of making informed decisions to ensure forest monitoring and improve forest damage monitoring. In addition to existing forest monitoring systems, such as forest inventory, crown condition survey, and forest soil inventory, systematic studies of forest condition and vulnerability on a national scale can be expanded with the help of satellite observation systems. observation is on the ground. In this review, we analyzed and classified all studies published over the last 20 years and devoted to remote sensing of forests in Kazakhstan.

Keywords: remote sensing, Earth observation, forest fund, forest monitoring, forest degradation, Kazakhstan, review

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Assessment of the ecological state of salinized lands on the territory of Kazakhstan

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Abstract. One of the main concerns of the modern era is the growth of saline soils in Kazakhstan. Scientists are becoming increasingly interested in land degradation, including the spread of saline soils.

Kazakhstan's soil cover has been significantly impacted by contemporary ecological issues, which are primary due to excessive human activity and the inappropriate usage of natural resources. In all of the Republic's natural zones, the state of the soil cover has gotten worse due to the ecological condition being unstable. The Republic spans a total area 272 million hectares, of which 222 million hectares are used for agriculture, including 27 million hectares are arable land. Unfavorable ecological conditions have emerged on the Republic's agricultural fields.

The southern regions of Kazakhstan experience a climate characterized by extreme drought, which leads to the prevalence of unsuitable soil cover in these areas. According to the scheme of natural and agricultural zoning of the land fund of the Republic of Kazakhstan, the region of deserts within the structural and accumulator plain of the Northern Aral Sea region is composed of the districts of Syrdarya and the Aral Sea. A map of soil salinization on the territory of Kazakhstan was made, which indicates that saline soils cover approximately 85% of the land area in Kyzylorda region (20.3 million hectares) out of a total of 22.6 million hectares of saline soils. Cartographic materials on Kazakhstan's salinized soils were taken under consideration for this study. It was discovered that Kazakhstan's central and southern regions are largely covered in saline soils.

Keywords: soil salinization, biodiversity, environmental factors, halophytes, population, component, agriculture, environmental degradation.

Introduction

The current demand for food and resources is strong due to the rapid rise of the population and economic growth. The requirements for the environment are continuously increasing, which leads to significant environmental problems [1]. Soil salinization refers to the accumulation salts that are soluble in the soil caused by certain natural factors, such as climate, hydrology and topography, or by a combination of destructive human factors and fragile ecological environments. This accumulation of salt deteriorates soil quality [2]. Soil salinization is one of the primary forms of desertification that the Earth and soil degradation as a resource and environmental problem that currently occurs on a large scale worldwide [3]. Alterations to the soil's chemical and physical composition affect the soil viability, whereas changes in the relevant substances and organisms affect the soil's chemical and physical characteristics. Also, It is a well known fact that microbes of soil are an important component of ecosystems.

Saline soils are a collective term for all types of soils in which salt components have a negative impact on the soil. The unique physicochemical-biological properties of saline soils are subject to various adverse effects. These include reduction in soil fertility and productivity levels, decrease in agricultural yields and harvests [4]. Waste of agricultural resources, instability of the ecological environment and other secondary threats cause [5]. Therefore, strengthening the administration and application of salinized soils, monitoring and determining accurate salinization information, as well as mastering the salinization level of regional arable land were important goals for scientists to study and overcome. As important real and potential arable land resources, saline soils have strong development and utilization value. Various saline soil types can be managed and improved by applying various effective soil improvement tools and other comprehensive measures in terms of their attributes that are chemical, physical, and biological, thus improving the quality and productivity level of the soil [6].

Soil salinization is a major soil degradation problem affecting hundreds of countries around the world. Salinization affects more than 1 billion hectares of land and its productivity, leading to a 50% reduction in global food production in the 21st century, accounting for approximately US\$1.27-2.73 billion in annual global agricultural expenditure. Arable land affected by soluble salts is distributed mainly in China, India, Pakistan, Iran, Australia and the United States. Climate and topography are primary motivating elements that determine the accumulation and dissolution salts that are soluble in the soil [7,8].

Climate and topography are the primary motivating elements that determine the accumulation and dissolution of soluble salts in the soil. In processes such as evaporation, water vapor transport, condensation, infiltration and effluent in the water cycle, salt accumulation in the soil and moisture transport are limited. Extreme soil temperatures, limited precipitation and increased evaporation, significantly increase the movement of water inside the soil and accelerate the process of soil salinization [9,10]. Changes in global climate patterns leading to soil moisture and drying cycles directly influence the trajectory of soil salinization or desalination. The main global trends in soil salinization over time have a significant impact on soil stability and arable land productivity [11].

Several studies on soil salinization in the area of Central Asia show the challenges and potential for agricultural development. He identified possible secondary salinization hazards in the deep layers of the soil and predicted that as the advancement of the irrigation system, the likelihood of secondary salinization in northern Kazakhstan will be higher. He noted the gradual an increase in salinity in the Aral Sea basin's irrigated areas, which suggests a danger to the potential development of Kazakhstan's agricultural and food security [12,13].

The industrialization of the world, the unplanned urbanization of many countries, climate change and various types of land degradation are all contributing to a rapid decline in land availability for agriculture, particularly in developing nations [14]. Additionally, about half of the world's irrigated land is on soils impacted by salt according to [15]. According to estimates over 800 million hectares of the world are affected by salinity, and this number is projected to rise by 2050, Over half of all arable land on Earth is predicted to become salinized [16,17]. Based on estimates, the impact of soil salinization due to inadequate irrigation practices is responsible for the destruction of approximately 60 million hectares of irrigated land globally, representing 24% irrigated land overall area. Salinization is the initial stage of environmental degradation caused by salinity, and is linked to the salinity of rivers and lakes [18]. Latin America is responsible for 14% of the degraded lands in the world. This region is characterized by a geological history, topographical features, climate and vegetation, which have resulted in a high diversity of soil types, with over 30 types of soils. Furthermore, Latin America is home to the largest concentration of megadiverse countries on the planet, with 6 of the 17 largest countries in the world being located in Latin America [19]. Thus, the purpose of this research was to perform a thorough evaluation of soil salinization in Latin America.

The total area of saline soil in Kazakhstan is 111.55 million, which is 41% of the country's territory. Even in the Kyzylorda region, which had undergone the calamity of the Aral Sea, there are 73,307 thousand hectares of irrigated land are in the dissatisfying condition. Most irrigated land needs to be completely improved. In addition, all of the above factors also have a major influence on the development of animal husbandry [20]. However, lack of water or the inability to obtain water impacts the growth of livestock. Concurrently, the productivity of high-quality agricultural products and the development of animal husbandry can lay a good foundation for economic stability in the region and the whole country. Rational use of saline soils and reclamation of empty land are one of the systemic issues in the agrarian sector of Kazakhstan [21]. Theoretical and technological research on saline soil management in Kazakhstan has been steadily developing. The country attaches great importance to the treatment and utilization of saline soils, policy research, and technological innovation. The study's objective mentioned in the article was to create a mapping and ecological assessment of saline lands and saline lakes in the territory of Kazakhstan.

Materials and research methods

The environmental situation of saline lands on the territory of Kazakhstan is a serious problem that directly affects the spheres concerning water resources and agriculture management. Kazakhstan, due to its large territory, includes different climatic zones, but predominantly

arid and semi-arid climate prevails. Soil salinization is a very serious problem in these regions, which becomes a serious problem due to inefficient irrigation systems and low natural rainfall.

Currently, the state's legal requirements for environmental protection are constantly being tightened. In this context, the main objective has been to solve environmental problems such as the lack of land resources of the country, the destruction of biodiversity and the salinization of the land.

In order to assess the environmental impact of salinized lands and salt lakes on the territory of the Republic of Kazakhstan, maps were compiled. To reveal environmental problems in Kazakhstan, cartographic methods using GIS, monitoring, analytical, comparative geographical, and formal assessment methods were employed.

The initial data was analyzed using geoinformation methods in the ArcGIS 10.6 software environment.

Saline areas on the territory of Kazakhstan are displayed in Figure 1

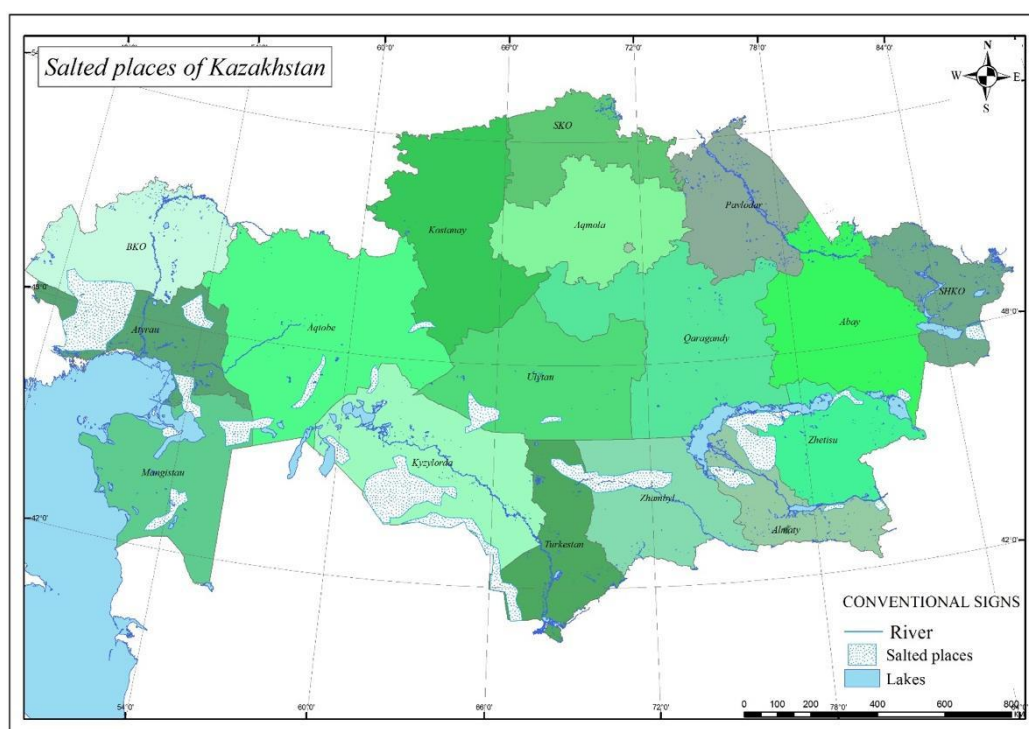


Figure 1. Map of saline areas of Kazakhstan

Note: created based on the author

Figure 1, the problem of salinization of the Aral Sea area is a big environmental problem for Central Asia. In this region, due to excessive irrigation and lowering of the Aral Sea water level, the concentration of salts in the soil has increased. The accumulation of salts has significantly reduced the productivity of regional agriculture, which has led to the destruction of local ecosystems and environmental catastrophe [22].

It is required to take comprehensive measures to solve the salinization problem in the Priaralie region. These include such methods as effective water management, improvement of drainage systems and introduction of salt-tolerant plant species. Such measures help to preserve soil fertility and improve the ecological condition of the region. For example, the saline areas in the River Syrdarya valley demonstrate the intricacy of the salinity problem in Kazakhstan. Widespread irrigated agriculture and inappropriate water use strategy in this region have led to increased soil salinization. As a result, it negatively affected the stability of agro-ecosystems and caused a decrease in productivity.

Another obvious example is the desert areas of the Mangistau region in Western Kazakhstan. Here the problem of salinization is mainly related to natural factors - i.e. very high evapotranspiration and little precipitation. These conditions lead to the accrual of salts in the soil, which negatively affects plant growth [23]. In addition, the Aral Sea region demonstrates the complexity of the salinization problem. The drying of the sea and lowering of water levels have led to large-scale salinization of coastal areas. This situation, in turn, has caused enormous damage to local ecosystems and people's livelihoods. Various strategies is applicable for addressing salinization in these areas, such as introducing salt-tolerant crops, improving drainage systems and using effective water management practices. Analyzing the salinity problem plays a significant impact in these regions in developing a strategy to combat salinization in Kazakhstan.

Results and discussions

Based on FAO, about 60% of the population of Central Asia depends on agriculture as a source of food and income. At the same time, 40-60% of the irrigated land in the area is saline or waterlogged. Turkmenistan (68% of the total area), Uzbekistan (51%), Kazakhstan (50-60%) and Turkey (30%) are among the countries most affected by salt.

The strain on Central Asia's scarce agricultural land is increasing due to rapid population growth and climate change [24]. The increase in population in the region and the expansion of irrigation practices increased the issue of salinization of the soil and decreased the flow of large rivers that run into the Aral Sea, like the Syrdarya and Amu Darya rivers [25]. In addition, The beginning of the twenty-first century has seen a rise in temperature by 1-2 °C with a high rate of evaporation Crop production and agricultural development in Central Asia are impacted by the melting of glacial reservoirs in the Tiashan and Pamir Mountains [26].

The map shows that 85% of the entire land area (20.3 million ha) of Kyzylorda region, which is among the biggest agricultural regions of Kazakhstan, is currently saline. There are a total of about 48,000 lakes in Kazakhstan, most of which are salt lakes. Twenty-four large salt lakes have been identified and these salt lakes have been mapped. The reason for the danger of saline lakes is that if the water in the lake decreases and dries up, it will have a negative impact on all surrounding vegetation, soil and living organisms in general. This reduces the productivity of agricultural fields and the wind-borne salt leads to soil salinization.

Salt lakes on the territory of Kazakhstan are displayed in Figure 2.

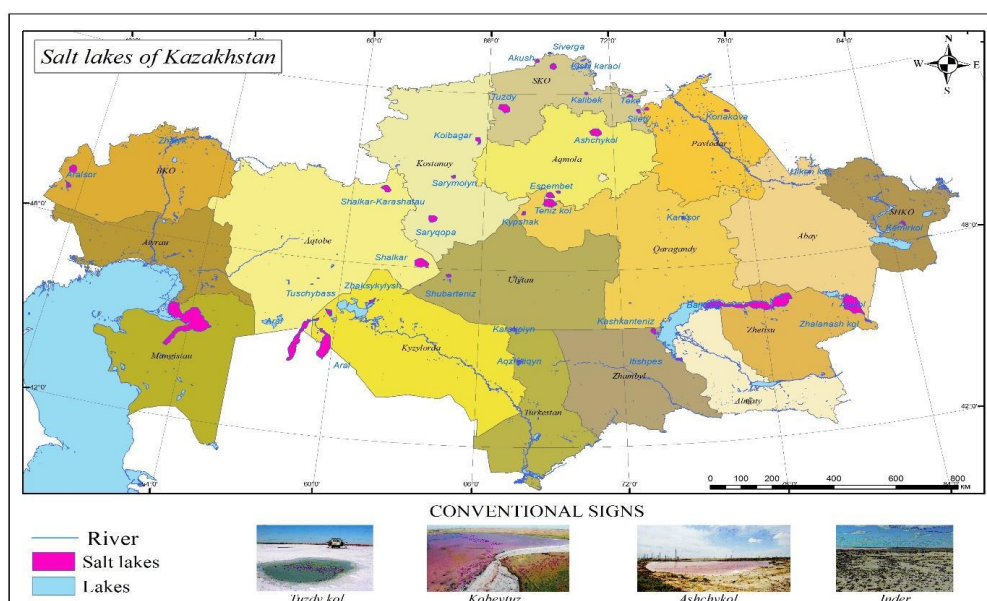


Figure 2. Map of salt lakes in Kazakhstan

Note: created based on the author

Figure 2, one of the TuzdyKol is salt lakes placed in the region of North Kazakhstan. Rivers do not flow into the lake, the main source is underground water and salty springs. Mud near the lake is an irreplaceable medicine. A large number of pilgrims from all over the world and Kazakhstan come here because of its healing properties. Salt reserves are about 647 million tons. But even if people come and get treated there, there are no conditions for curing people because it is a barren field.

Kobeituz is a drainless salt lake in Kazakhstan, the lake length - 3.5 km, width - 3.1 km, area - 6 km. Water mineralization is 334 g/l. Water is replenished by precipitation and groundwater. In a few years, this lake turns pink. The reason for the pink color is the increase in the biomass of the algae "Dunaliella salina". Since it has become known for its pink color, this lake has become a frequent tourist destination. The saddest part is that this lake is getting polluted due to human impact. The rise in the quantity of people interested in its beauty affects the loss of the pink color of the lake and also the shores of the lake are heavily polluted [27].

Aschykol is a salt lake without water, located in Talas district of Zhambyl region of South Kazakhstan. The height of Aschykol is 400 meters above sea level. The lake is not very large, its length is 300 kilometers and width is 500 meters. When the water in Lake Aschykol decreases, salt crystals appear on the surface of the lake.

Lake Inder is located near the Zhaiyk River. It is a drainless salt lake placed the northern part of the Caspian basin. It has an area of 110 square kilometers. It starts from underground salt springs and neighboring mountains and continuously flows and connects with rainwater, transporting salt. The lake water contains potassium, bromine, boron and high quality salts. Salt mining is also carried out. The thickness of the salt layer reaches 10-15 meters in some places. The lake's mud is used for therapeutic purposes. Pollution due to anthropogenic impact.

Lake Maraldi is a salt lake located in Sharbakti settlement of Pavlodar district, Pavlodar region. Its area is 54.2 square kilometers, length - 9.5 kilometers, width - 8.3 kilometers, catchment area - 773 square kilometers. Lake Maraldi is a salt lake known worldwide for its medicinal clay. As a result of research of dry residue of soil near Maraldi Lake in Pavlodar region it was found that soil salinity is very high. According to the method of N.I. Bazilevich, E.I. Pankova, in accordance with the quantity of toxic salts in the soil, it was found that $Cl^{-}:SO_4^{2-} = 0,80 > 0,6$ in soil samples refers to saline soil [28].

Lake Alakol is a salty and warm lake located in the east of the country, bordering China. Alakol is sometimes compared to the Black Sea. The quantity of salt in the lake reaches 11.6 grams per liter. In terms of salinity, this lake is approximately equal to the Black Sea and the Sea of Azov. It is famous for its healing mud. The number of tourists is increasing, the level of pollution is also growing. Salty, healing mud is rich in mineral salts. The ecological situation worsens every year.

In general, it is known that on salinization of partial lakes shown on the map, the influence of natural factor prevailed over anthropogenic factor. However, it is recognized that the majority of saline lakes in Kazakhstan were formed as a result of drought or water abstraction processes. As for the Aral Sea, the influence of anthropogenic factor prevails here. As a result of the Aral Sea's rivers being used for agricultural purposes, water has been withdrawn. Conversely, the territory where the Aral Sea is located is in a desert zone, and the rapid evaporation process has led to the lake's drying up and increase of its salinity.

Map of saline lands within the Kazakhstani Republic showing the distribution of these regions, their size and geographical location. Zones highlighted in red color on the map indicate places of the greatest impact of salinization, they are located mainly in Mangistau and Atyrau regions, in addition to the area surrounding the Aral Sea. Deterioration of soil quality on these lands negatively affects agro-ecosystems and leads to economic losses, as the productivity of farming and livestock farming on these lands decreases.

Saline lands and saline lakes in Kazakhstan are displayed in Figure 3.



Figure 3. Salt lakes and saline areas of Kazakhstan

Note: created based on the author

In Figure 3, Kazakhstan is divided into 3 major regions based on saline areas. All three of them are located in South Kazakhstan. The main accumulation of sulfate-chloride and chloride salts is because to accumulation in the Aral and Caspian Sea basins, as well as sodium sulfate salt in Balkhash. There are standing lakes in each of these three areas, which accumulate both salt and water [29].

Salt accumulation negatively affects the soil's chemical and physical characteristics. For example, high salt concentration destroys soil structure, reduces water permeability and air exchange, which hinders the development of plant roots and reduces soil fertility. In addition, salinization creates a stress situation that hampers plant growth because salts reduce the capability of plants to use water efficiently [30].

Conclusion

Proper management of salt soil resources in Kazakhstan depends on national food security and environmental sustainability. Heads of state attach great importance to the management and disposal of salt soils. As an important land resource in Kazakhstan, saline soils of various types, vast territories and great potential provide unique research conditions for our researchers. Effective and accurate monitoring of salinization information, along with management and development of unused saline soils, provides more opportunities for development to expand the country's arable land and expand the path of agricultural development. Kazakhstan has a significant impact on National Food Security, arable land security, salt land improvement, land use protection, ecology and sustainable agricultural development. The search for more effective, reliable, accurate and cost-effective technologies for monitoring soil salinization is becoming increasingly important in today's increasingly complex conditions of soil salinization.

In order to understand the ecological condition of saline areas and improve it, a map of saline areas and Kazakhstan's salt lakes was created. Based on the created maps, the dynamics of the salinization process will be monitored and it will be determined how it is changing and what factors affect it. In addition, through the application of novel techniques and technology meant to mitigate the consequences of salinization, It has a significant impact on maintaining and even restoring soil fertility. Thus, as a consequence of our investigation, Research on transforming salinized soil into productive land resources is vital.

Authors' contributions:

Conceptualisation – **Zh. Rakhymzhan** and **M.Zh. Mirzabekova**; methodology – **Zh. Rakhymjan** and **Z.Zh. Nurgalieva**; validation – **R.M. Tazitdenova** and **N.S. Ergazina**; Investigation – **A.D. Rakhisheva** and **N.S. Yergazina**; preparation of the original draft – **Zh. Rakhymzhan** and **M. Zh. Mirzabekova**; writing and editing of the review – **Zh. Rakhymzhan**. All authors have read and agreed with the published version of the manuscript.

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Қазақстан аумағындағы тұзданған жерлердің экологиялық жағдайын бағалау

Аңдатпа. Қазақстанда тұзды топырақтардың көбеюі қазіргі кездегі басты мәселелердің бірі болып табылады және ғалымдар кең таралған тұзды топырақтар сияқты жердің деградациясына үлкен қызығушылық таныта бастады. Қазақстанның топырақ жамылғысына адамзаттың шамадан тыс белсенділігі мен табиғи ресурстарды дұрыс пайдаланбауынан туындаған заманауи экологиялық мәселелер әсер еткені сөзсіз. Республиканың барлық табиғи аймақтарында экологиялық жағдайдың тұрақсыздығына байланысты топырақ жамылғысының жағдайы нашарлады. Республика жалпы аумағы 272 миллион гектарды алып жатыр. Ауыл шаруашылығына 222 миллион гектар жер пайдаланылса, оның 27 миллион гектары егістік алқаптар. Республиканың ауыл шаруашылық алқаптарында қолайсыз экологиялық жағдайлар туындады.

Қазақстанның оңтүстік өңірлерінде климат өте құрғақшылықпен ерекшеленеді. Сондықтан мұндай аумақта жарамсыз топырақ жамылғысы басым болады. Қазақстан Республикасының жер қорын табиғи және ауыл шаруашылық аймақтарға бөлу схемасына сәйкес, Солтүстік Арал аймағының құрылымдық және аккумуляторлық жазығындағы шөлдер аймағы Сырдария және Арал аудандарынан тұрады. Қазақстан аумағында топырақтың тұздануының картасы жасалды. Мәліметтерге сәйкес, қызылорда облысы аумағындағы тұзды топырақтар қазіргі уақытта облыстың бүкіл жер көлемінің (20,3 млн га) 85% - ын (22,6 млн га) дерлік тұзды жерлерді құрайды. Бұл зерттеу үшін Қазақстанның сортаң топырағы бойынша картографиялық материалдар пайдаланылды. Қазақстанның орталық және оңтүстік аймақтары сортаң топырақтарды негіз ететіндігі анықталды.

Түйін сөздер: топырақтың сортаңдануы, биологиялық әртүрлілік, экологиялық факторлар, галофиттер, популяция, құрамдас бөлік, ауылшаруашылығы, қоршаған ортаның деградациясы.

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Оценка экологического состояния засоленных почв на территории Казахстана

Аннотация. Распространение засоленных почв в Казахстане в настоящее время является одной из основных проблем, и ученые начали проявлять большой интерес к деградации земель, таким, как широко распространенные засоленные почвы. Современные экологические проблемы, вызванные чрезмерной деятельностью человека и нерациональным использованием природных ресурсов, безусловно, сказались на почвенном покрове Казахстана. Во всех природных зонах республики состояние почвенного покрова ухудшилось из-за нестабильной экологической обстановки. Общая площадь республики составляет 272 миллиона гектаров. 222 миллиона гектаров используются в сельском хозяйстве, из которых 27 миллионов гектаров - пахотные земли. На сельскохозяйственных полях республики сложилась неблагоприятная экологическая обстановка.

Климат южных регионов Казахстана характеризуется сильной засухой. Поэтому на этой территории преобладает непригодный почвенный покров. Согласно схеме природного и сельскохозяйственного районирования земельного фонда Республики Казахстан, область пустынь в пределах структурно-аккумулятивной равнины Северного Приаралья состоит из районов Сырдарьи и Аральского моря. Была составлена карта засоления почв на территории Казахстана. Согласно полученным данным, засоленные почвы на территории Кызылординской области в настоящее время составляют 85% всей площади области (20,3 млн га), почти 22,6 млн га засолены. Для данного исследования были использованы картографические материалы по засоленным почвам Казахстана. Выяснилось, что центральные и южные регионы Казахстана в значительной степени покрыты засоленными почвами.

Ключевые слова: засоление почв, биоразнообразие, экологические факторы, галофиты, популяция, компонент, сельское хозяйство, деградация окружающей среды.

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