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SYSTEMATIC ANALYSIS OF AQUATIC AND SEMI-AQUATIC FLORA OF THE UNIQUE WATER CHEMICAL COMPOSITION OF ZHALANASHKOL LAKE OF THE ALMATY REGION

Over the past century, the study of aquatic plants has expanded greatly due to the increased recognition of their importance in fundamental systemic processes.

Lake Zhalanashkol belongs to the soda lake type, as it is characterized by a unique chemical composition of water. Also, recently the anthropogenic contribution has increased due to the development of recreational activities in the nearby territory of the lake, therefore, the relevance and importance of studying the flora of Zhalanashkol lake in Almaty region is beyond any doubts.

The purpose of this article was to perform a systematic analysis of higher and semi-aquatic plants of Zhalanashkol soda lake in Almaty region.

It should be noted that at present, much more attention is being paid to the study of higher and semi-aquatic plants due to their wide practical significance. Higher aquatic plants perform the following functions in ponds: filtrative, absorptive, storaging, oxidizing, detoxifying. Also, this kind of plant is used as a raw material for paper, medicine and perfume industries, building materials and fertilizers.

Field (expeditionary) and route-reconnaissance research methods were used to perform the research.

As a result of the research, 46 species of higher and semi-aquatic plants belonging to 21 families and 43 genera were identified within Zhalanashkol lake flora. The floristic spectrum of the study area showed that the floral core is represented by angiosperms, and the minor part is represented by gymnosperms. 10 leading families of the study area include 34 species, which is 73.91% of the total number of identified species.

Thus, the species identification process of semi-aquatic vegetation makes it possible to characterize the ecological state of the ecosystem in detail. Nowadays, water analysis is commonly performed with the help of biological indicators, and is widely used in the practice of hydrobiological research.

Key words: Zhalanashkol, systematic analysis, flora, aquatic plants, semi-aquatic plants.

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Химиялық құрамы бойынша ерекше Алматы облысы Жалаңашкөл көлінің суы және жағалау-су флорасын систематикалық талдау

Соңғы ғасырда су өсімдіктерін зерттеу олардың іргелі жүйелік процестердегі маңыздылығын мойындаудың артуына байланысты едәуір кеңейді.

Жалаңашкөл көлі сода типіне жатады, сондықтан ол судың ерекше химиялық құрамымен сипатталады. Сондай-ақ, соңғы уақытта көлдің жақын маңдағы аумағында рекреациялық қызметтің дамуына байланысты антропогендік жүктеме өсті, сондықтан Алматы облысының Жалаңашкөл көлінің флорасын зерттеудің өзектілігі күмән тудырмайды.

Осы мақаланың мақсаты Алматы облысының Жалаңашкөл көлінің жоғары сатыдағы су және жағалау – су өсімдіктеріне жүйелі талдау жүргізу болды.

Айта кету керек, қазіргі уақытта олардың кең практикалық маңыздылығына байланысты жоғары сатыдағы су және жағалау – су өсімдіктерін зерттеуге көбірек көңіл бөлінуде. Су қоймаларында жоғары сатыдағы су өсімдіктері келесі функцияларды орындайды: сүзу, сіңіру, жинақтау, тотығу, детоксикация. Сондай-ақ, өсімдіктердің бұл түрі қағаз, медициналық, парфюмерия, құрылыс материалдары мен тыңайтқыштар үшін шикізат ретінде қолданылады.

Зерттеу жүргізу үшін далалық (экспедициялық) және маршруттық-барлау зерттеу әдістері қолданылды.

Жүргізілген зерттеулер нәтижесінде Жалаңашкөл көлінің флорасы құрамында 21 тұқымдасқа және 43 туысқа жататын жоғары сатыдағы су және жағалау-су өсімдіктерінің 46 түрі анықталды. Зерттелетін аумақтың флорасының флоралық спектрі флораның негізі гүлді, ал ең аз бөлігі гимноспермалар екенін көрсетті. Зерттелген аумақтың 10 жетекші отбасының 34 түрі бар, бұл анықталған түрлердің жалпы санының 73,91% құрайды.

Осылайша, жағалау-су өсімдіктерінің түрлік құрамы экожүйенің экологиялық жағдайын дәл сипаттауға мүмкіндік береді. Қазіргі уақытта гидробиологиялық зерттеулер тәжірибесінде кеңінен қолданылатын биологиялық көрсеткіштер бойынша суды индикациялау әдістемесі кеңінен қолданылады.

Түйін сөздер: Жаланашколь, систематикалық талдау, флора,сатыдағы су өсімдіктері, жағалау – су өсімдіктері.

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Систематический анализ водной и прибрежно-водной флоры уникального по химическому составу воды озера Жаланашколь Алматинской области

За последнее столетие изучение водных растений значительно расширилось из-за возросшего признания их важности в фундаментальных системных процессах.

Озеро Жаланашколь относится к содовому типу, поэтому оно характеризуется уникальным химическим составом воды. Также, в последнее время возросла антропогенная нагрузка, в связи с развитием рекреационной деятельностью на близлежащей территории озера, поэтому, актуальность исследования флоры озера Жаланашколь Алматинской области не вызывает сомнения.

Целью данной статьи было провести систематический анализ высших водных и прибрежно – водных растений содового озера Жаланашколь Алматинской области.

Необходимо отметить, что в настоящее время все большее внимание уделяется исследованию высших водных и прибрежно – водных растений, в виду их широкой практической значимости. Высшие водные растения в водоемах выполняют следующие функции: фильтрационную, поглотительную, накопительную, окислительную, детоксикационную. Также данный тип растений используется в качестве сырья для бумажной, медицинской, парфюмерной промышленности, строительных материалов и удобрений.

Для проведения исследований использовался полевой (экспедиционный) и маршрутно-рекогносцировочный методы исследований.

В результате проведенных исследований, было выявлено, что в составе флоры озера Жаланашколь выявлено 46 видов высших водных и прибрежно-водных растений, относящихся к 21 семейству и 43 родам. Флористический спектр флоры исследуемой территории показал, что основу флоры составляют цветковые, а минимальную часть голосеменные растения. На долю 10 ведущих семейств изучаемой территории приходится 34 вида, что составляет 73,91 % от общего количества выявленных видов.

Таким образом, видовой состав прибрежно-водной растительности позволяет точно охарактеризовать экологическое состояние экосистемы. В настоящее время широко используется методика индикации воды по биологическим показателям, которая широко применяется в практике гидробиологических исследований.

Ключевые слова: Жаланашколь, систематический анализ, флора, водные растения, прибрежно-водные растения.

Introduction

Zhalanashkol is a lake located on the border of the Alakol district of Almaty region and Urdzhar district of East Kazakhstan region. It is located in the north-western part of the Dzungarian Gate at a distance of 50 km south-east to Koktuma village. Lake Zhalanashkol is a part of the Alakol (Alakol-Sasykkol) lake system. The area of Zhalanashkol is 38 km^2, the length is 9 km, the width is 5.6 km, and the length of the coastline is 24 km. The lake is relatively shallow: its maximum depth is 5.5, the average depth is about 3 m. [1].

Zhalanashkol lake has no permanent tributaries, the water regime is maintained due to ground water feeding and a small amount of rain and snowmelt water. Water is significantly mineralized and might be characterized by having medicinal properties [2-3].

According to the classification of Boros E. and Kolpakova M. [4] the lake belongs to the soda-saline type of lakes based on the former data from Filonets P. [5] while it had a soda type composition in 2021, based on our latest measurement and Akhmetzhanova A. [6]. Soda type: when Na+ and sum of HCO3– + CO32– – are the first in the rank of dominant ions (> 25e%), while soda-saline: Na+ is ranked first among the dominant cations (> 25e%), but the sum of HCO3– + CO32– is not of the most dominant component of the anions (> 25e%).

Since Zhalanashkol recently lake belongs to the soda lake, it is characterized by a unique chemical composition of water [7]. Also, the anthropogenic load has been increased recently, due to the development of recreational activities in the nearby territory [8], therefore, study relevance of Zhalanashkol flora in the Almaty region is beyond any doubts. It should be noted that currently much more attention is being paid to the study of higher and semi-aquatic plants due to their wide practical significance. That is, the prospects of using aquatic and semi-aquatic plants are of the greatest interest among researchers. Higher aquatic plants perform the following main functions in reservoirs: filtrating (it contributes to the sedimentation of suspended substances); absorpting (towards biogenic elements and some organic substances); accumulative (due to the ability to accumulate some metals and organic substances that are difficult to decompose); oxidative (due to photosynthesis water is enriched by oxygen); detoxifying (plants are able to accumulate toxic substances and convert them into non-toxic) [9-13].

The purpose of this article was to conduct a systematic analysis of the highest aquatic and semi-aquatic plants of Zhalanashkol lake in Almaty region.

Materials and methods

Field (expeditionary) and route-reconnaissance research methods were used to perform the research [14]. The field (expeditionary) research method is intended to familiarize the ground with the objects (point and area) of future research and is associated with the collection of primary source data intended for further processing in stationary (desk) conditions [15]. The route-reconnaissance method is based on the identification of main patterns of species distribution and vegetation in the study area.

Before starting the work, several observational points of Zhalanashkol lake were chosen (Figure 1) on the territory of Almaty region. Geobotanical vegetation description was carried out on separate small-area plots, as well as herbarization of the chosen plants and their entry into geobotanical forms. The route had been planned in such a way that it would trespass various plant communities, capturing a variety of habitats.

Figure 1 – The research area of Lake Zhalanashkol (N 45°34’58.06” E 82°6’59.50”, N 45°34’15.42” E82°6’55.45”)

The collection of aquatic plants, unlike terrestrial ones, has a number of distinctive features. The collection and drying of herbarium material was carried out according to the method of Lisitsina L.I. [16].

Herbarium samples were determined using literature: "USSR Flora", "Kazakhstan Flora", "Illustrated plant guide of Kazakhstani plants"; the determination of families and genera was performed with the help of "Flora of Kazakhstan" written by Baitenov M.C. [18-19].

The disposition of species and supraspecific categories of flora and floristic spectrum was performed according to the system of Takhtajan A. L. [20]. The spelling of Latin names, the nomenclatural taxa variations were verified in accordance with Cherepanov S. K. [21].

Results and discussions

The systematic structure of flora is understood as a complete territorial summary of supraspecific taxa of plants of one rank or another. The characteristic basic feature of any flora is its systematic composition, the main qualitative indicator of which is considered to be floral diversity, determined by the number of species, genera and families [22]. The flora of Zhalanashkol lake includes 43 genera and 46 species of higher aquatic and semi – aquatic members from 21 families. Figure 2 shows data on the systematic composition of the study area.

The leading position is occupied by the family of *Chenopodiaceae* Vent., which includes 6 genera (*Atriplex, Camphorosma, Ceratocarpus, Chenopodium, Salsola, Suaeda*) and 8 species. *Asteraceae* Dumort. includes 5 genera (*Achillea, Artemisia, Scorzonera, Tragopogon, Xanthium*) and 5 species. *Poaceae* Barnhart includes 4 genera (*Achnatherum, Phragmites, Poa, Setaria*) and 4 species. *Haloragaceae* R.Br. has 4 genera (*Myriophyllum, Glycyrrhiza, Trifolium, Vicia*) and 4 species. *Polygonaceae* Juss. has 3 genera (*Polygonum, Rheum, Rumex*) and 3 species. There are families, which include 2 species and 2 genera, and they are: *Cyperaceae* Juss. (genera: *Bolboschoenus, Carex*), *Euphorbiaceae* Juss. (genera: *Euphorbia, Potentilla*), *Brassicacea* Burnett (genera *Erysimum, Lepidium*), *Limoniaceae* Ser. (genera: *Limonium, Tamarix*), *Ranunculaceae* Juss. (genera: *Adonis, Ceratocephala*). 1 genus and 2 species representatives belong to *Ceratophyllaceae* S.F. Gray (*Ceratophyllum*), 1 genus and 1 species representative belongs to *Typhaceae* Juss. (*Typha angustifolia* L.), *Lamiaceae* Lindl. (*Mentha arvensis* L.), *Plantaginaceae* Juss. (*Plantago lanceolata* L.), *Convolvulaceae* Juss. (*Convolvulus arvensis* L.), *Nitrariaceae* Bercht.et J. Presl (*Nitraria schoberi* L.), *Onagraceae* Juss. (*Epilobium hirsutum* L.).

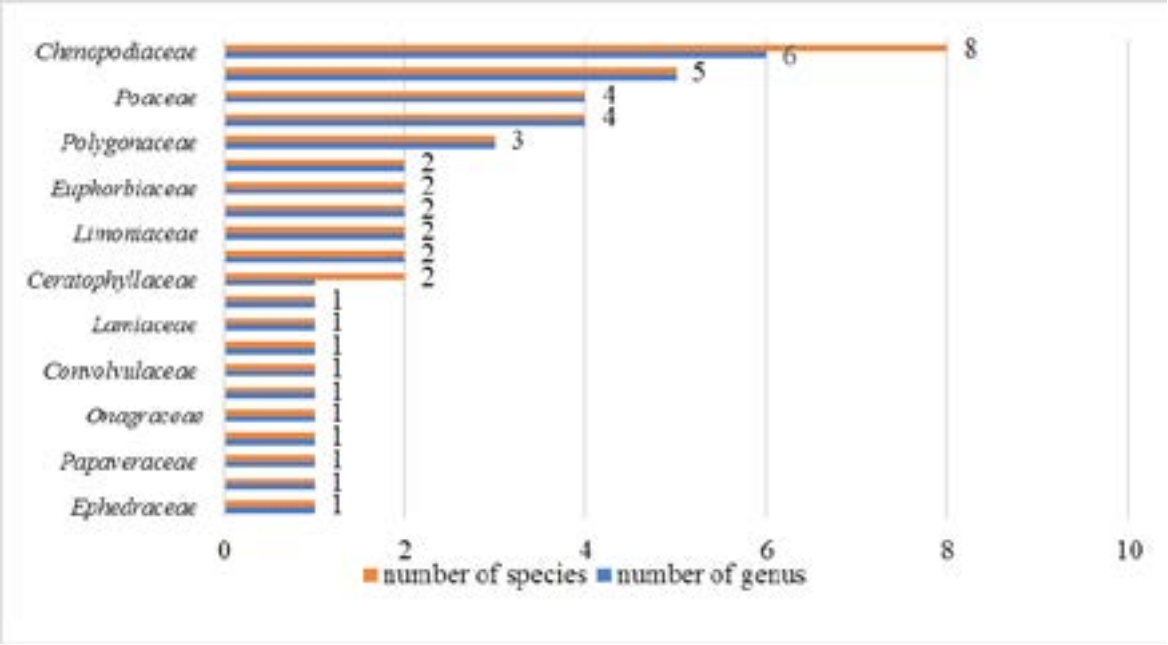

Figure 2 – Family spectrum of Lake Zhalanashkol

The presence of families having one-two species representatives within the flora is of great interest, since the core of their species diversity can also be found in other climatic zones. The floral spectrum of Zhalanashkol lake and the above-mentioned systematic groups show that the main floral part consists of angiosperm representatives, and the minor part is taken by gymnosperm representatives.

Table 1 – Distribution of plants of Zhalanashkol lake by the systematic groups

Systematic group	Number of families	Number of genus	Number of species	% of the total number of species
Gymnosperms	1	1	1	2.17
Angiosperms: - dicotyledons - monocotyledons	 18 3	 35 7	 38 7	 82.6 15.2
Total:	21	43	46	100

Table 1 illustrates that the species composition of Zhalanashkol lake is dominated by the Angiosperms, which accounts for 45 species (97.8%) and only 1 species or 2.17% belong to the Gymnosperms.

The ratio of monocotyledonous and dicotyledonous groups is approximately 1:5, i.e. *Magnoliopsida* class prevails over *Liliopsida* due to species diversity represented 5 times more. The total number of monocotyledons consists of 7 species or 15.2% of the total number of species; while dicotyledonous plants include 38 species or 82.6%.

Thus, in the studied flora, the majority of families, genera and species belong to angiosperms, among which dicotyledons dominate.

Flora analysis in modern floristics is performed by distinguishing 10 leading families that mostly represent main part of the floral spectrum (Figure 4).

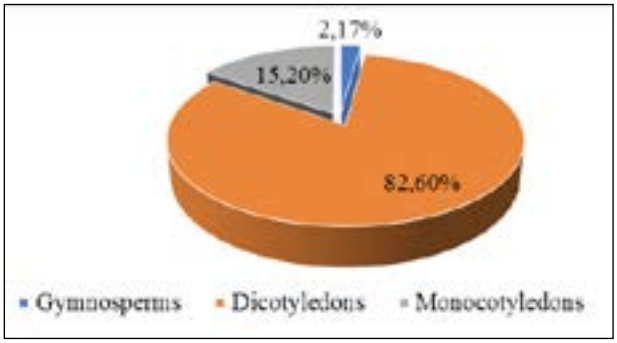

Figure 3 – Ratio of systematic groups

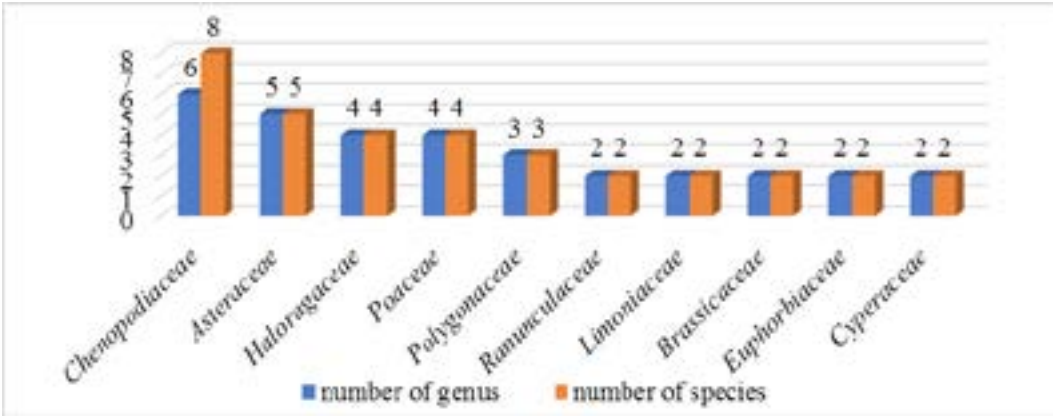

Figure 4 – Number of species and genera in 10 leading families

10 dominant families include 34 species, which accounts for about 73.91 % of the total number of species. According to the data, the first place in the number of species and genera is occupied by the *Chenopodiaceae* family (8 species, or 17.39% of the total number of species, 6 genera): *Camphorosma lessingii* Litv., *Ceratocarpus utriculosus* Bluk., *Atriplex tatarica* L., *Chenopodium album* L., *Ch. rubrum*, *Salsola arbuscula* Pall., *S. collina* Pall., *Suaeda crassifolia* Pall. The second place is taken by the families *Asteraceae* (5 species or 10.87 % of the total number, 5 genera): *Achillea millefolium* L., *Artemisia absinthium* L., *Scorzonera songorica* (Kar.et Kir.) Lipsch. et Vass., *Tragopogon dubius* Scop., *Xanthium strumarium* L. Families *Haloragaceae* (*Myriophyllum spicatum* L., *Glycyrrhiza glabra* L., *Trifolium pratense* L., *Vicia cracca* L.) and *Poaceae (Achnatherum splendens* (Trin.) Nevski*, Phragmites australis* (Cav.) Trin. ex Steud., *Poa angustifolia* L*., Setaria viridis* (L.) Beauv*.),* which include the same number of species and genera (4 species or 8.69 % of the total number species, 4 genera). Family *Polygonaceae* includes 3 genera and 3 species: (*Polygonum aviculare* L., *Rheum nanum* Siev., *Rumex stenophyllus* Ledeb.) Two families are at the bottom of top ten leading families with the same number of genera and species, which is 2: *Limoniaceae* (*Limonium gmelinii* (Willd.) O. Kuntze, *Tamarix ramosissima* Ledeb.), *Brassicaceae* (*Erysimum canescens* Roth, *Lepidium ruderale* L.), *Euphorbiaceae* (*Euphorbia humifusa* Schlecht., *Potentilla recta* L.) and *Cyperaceae* (Bolboschoenus maritimus (L.) Palla., *Carex physodes* Bieb.).

At the same time, it should be mentioned that taxa, including a relatively small number of species, play the same important role as taxa having a larger number of species, considering the vegetation cover. An example is the family *Limoniaceae* Ser., whose representative is *Limonium gmelinii* (Willd.) O. Kuntze – this is a bioindicator of elevated salt levels of water and coastal territory, the presence of which is caused by excessive water salinity.

The leading genera include *Ceratophyllum demersum* L. and *Ceratophyllum submersum* L. from the family of *Ceratophyllaceae* S.F. Gray, *Chenopodium album* L., *Ch. rubrum* L., *Salsola arbuscula* Pall., *S. collina* Pall. from the *Chenopodiaceae* Vent family. The species of these genera form a floral background in appropriate ecological conditions. However, the roles of individual genera and families within the flora do not always correspond to their role in the vegetation cover when it comes to aquatic and semi-aquatic vegetation. In the studied flora, in this regard, the genera *Typha angustifolia* L., *Phragmites australis* (Cav.) Trin.ex Steud., *Bolboschoenus maritimus* (L.) Palla can be a good example: they form a core of aquatic and semi – aquatic vegetation of Zhalanashkol lake. The following aquatic plants should also be noted in the same regard: *Ceratophyllum demersum* L., *C. submersum* L., *Myriophyllum spicatum* L.

The content of plant communities and their distribution is determined by environmental conditions. The main factors determining vegetation distribution within the aquatic environment are: salt level, pH, transparency, turbidity, light conditions, etc. However, the growth of terrestrial species depends on humidity and light conditions, soil salinity, mechanical composition, geomorphological conditions, and precipitation.

Figure 5 – Cattails-mixed-grass community of Zhalanashkol lake

Figure 6 – Grass – mixed community of Zhalanashkol lake

The main part of the study area is dominated by the mix of typha and grass communities dominated by typha (*Typha angustifolia* L.) and reed grasses (*Phragmites australis* (Cav.) Trin.ex Steud.), as well as grasses and forbs. The plant cover is 80% (Figure 5-6).

The 72 useful species are identified on the territory of the study. Ilyins M.M. classification was used as a foundation for group plant group distinguishment [23]. Thus, three major types have been identified, each of them includes several feature groups of useful plants. The quantitative ratio is presented in table 2.

Table 2 – Distribution of groups of useful plants by special types

Type	Groups of useful plants	The number of species
Natural	Medicinal	10
	Fodder	19
	Food	6
	Honey	4
	Venomous	6
	Insecticidal	1
	Decorative	2
Technical	Essential oil	3
	Fat oil	2
	Tanning	5
	Dyeing	4
	Fibrous	3
	Wicker	5
	Fuel and wood	2
Total:		72

The natural type includes plants with the following features: medicinal, fodder, food, honey, poisonous, insecticidal, and decorative. The most numerous in their number are fodder plants, there are 19 species: *Ceratophyllum demersum* L., *Salsola arbuscula* Pall., *Salsola collina* Pall., *Polygonum aviculare* L., *Rheum nanum* Siev., *Glycyrrhiza glabra* L., *Trifolium pratense* L., *Vicia cracca* L., *Achillea millefolium* L., *Bolboschoenus maritimus* (L.) Palla, *Achnatherum splendens* (Trin.) Nevski, *Phragmites australis* (Cav.) Trin.ex Steud., *Poa angustifolia* L., *Setaria viridis* (L.) Beauv., *Typha angustifolia* L.

The next group is medicinal plants, which includes 10 species. Some of them are: *Hypericum perforatum* L., *Chelidonium majus* L., *Limonium gmelinii* (Willd.) O. Kuntze, *Glycyrrhiza glabra* L., *Artemisia absinthium* L. etc.

Groups of edible and poisonous plants each contain 6 species: *Hypericum perforatum* L., *Chenopodium album* L., *Ch. rubrum* L., *Glycyrrhiza glabra* L., *Bolboschoenus maritimus* (L.) Palla, *Typha angustifolia* L. can be used in food industry. *Adonis parviflora* Fisch. ex DC., *Ceratocephala testiculata* (Crantz) Bess., *Chelidonium majus* L., *Gypsophila paniculata* L., *Lepidium ruderale* L., *Xanthium strumarium* L. are poisonous ones, accordingly.

Honey plants include 4 species: *Epilobium hirsutum* L., *Trifolium pratense* L., *Vicia cracca* L., *Mentha arvensis* L.

2 decorative plant species were identified: *Gypsophila paniculata* L., *Tamarix ramosissima* Ledeb. However, there is only 1 type of insecticidal plant species: *Lepidium ruderale* L.

Technical plant types include plants containing essential oils and fat oils, and plants with a potential use in tanning, dying, fiber, wick, fuel and wood industries. 5 plant species belong to tanning plant types and they are *Polygonum aviculare* L., *Rheum nanum* Siev., *Limonium gmelinii* (Willd.) O. Kuntze y Dyeing plants include 4 species, and they are *Hypericum perforatum* L., *Polygonum aviculare* L., *Xanthium strumarium* L., *Chenopodium rubrum* L. Wicker plants (*Achnatherum splendens* (Trin.) Nevski). Plants containing essential oils include 3 species (*Mentha arvensis* L., *Achillea millefolium* L. and etc.). Plants containing fats are *Xanthium strumarium* L. and etc., fibrous plants are *Glycyrrhiza glabra* L. and etc. Plants with a potential use in fuel and wood industry include 5 species, and an example is *Salsola arbuscula* Pall.

Conclusion

As a result of the systematic analysis of higher aquatic and semi – aquatic plants of Zhalanashkol soda lake in Almaty region, 46 species from 43 genera belonging to 21 families were identified. The triad of dominant families is identified too: it's *Chenopodiaceae* (6 genera, 8 species), *Asteraceae* (5 genera, 5 species), *Halogaraceae* and *Poaceae*, the latter ones have the same number of genera and species – 4. 10 dominant families contain 34 species, which is accounted for 73.91 % of the total number of species. The leading genera are *Ceratophyllum demersum* L. and *Ceratophyllum*

submersum L. from the family of *Ceratophyllaceae* S.F. Gray, *Chenopodium album* L., *Ch. rubrum* L., *Salsola arbuscula* Pall., *S. collina* Pall. from *Chenopodiaceae* Vent family.

72 useful species are identified on the territory of the study area. The most numerous groups are based on the number of species, and they are medical and fodder plants.

Thus, due to the peculiarities of the aquatic flora, the higher aquatic and semi – aquatic plants of Zhalanashkol lake of the Almaty region are characterized by a small species diversity, with a predominance of *Typha*, *Phragmites*, *Bolboschoenus*.

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Conflict of interest

All authors are familiar with information provided in the article and declare no conflicts of interest

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