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SOILS STATE ANALYSIS IN THE SEMI-AQUATIC ZONE OF SALINE AND SODA LAKES IN ZHETYSU (by the example of lake Alakol, Sasykkol, Zhalanashkol, Balkhash and Ushkol)

In the desert zone of Zhetysu, the vegetation cover of pastures is scarce and their fodder quality is very low. This is due to the dryness of the climate. The amount of atmospheric precipitation does not exceed 120-150 mm per year, most of which falls in the autumn-winter period. Summer is characterized by extreme dryness. The desertification of the territory that has been developing in recent years, the processes of soil salinization further reduce the productivity of desert pastures. Under these conditions, the vegetation cover of inland waterslocated in the desert zone is of particular interest in this article. Semi-aquatic zones of inland waters have a better wet conditionand have more developed vegetation. But not everywhere the vegetation of inland watersdevelops in the same way and it depends on edaphic conditions. Therefore, the soil studies of lakes' semi-aquatic zone located in the desert zone in particular seem to us relevant. The aim of the study is to investigate the edaphic conditions for the vegetation cover development in the semi-aquatic zone of saline and soda lakes in the desert of Zhetysu to increase their productivity and fodder value. For the research, both fields (comparative geographic, cartographic, route reconnaissance) and laboratory research methods were used. Based on the results obtained, it was revealed that there are non-saline soils (soils of semi-aquatic coastline of Zhalanashkol, Ushkol lakes), slightly saline (soils of Balkhash, Sasykkol lakes) and highly saline (soils of the semi-aquatic coastline of alakol lake) in the study area. The main type of salinization are soda-sulfate and chloride-sulfate. The results obtained can be used as a basis for monitoring studies and as a comprehensive assessment of Zhetysu soil. The results of the study will also make it possible to assess the degree of soil degradation and vegetation cover under saline conditions.

Key words: saltmarsh, salt licks, agrochemical analysis, water extract, higher – aquatic and semi aquatic plants, saline lakes, soda lakes.

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Жетісу тұзды және сода көлдерінің жағалау аймағындағы топырақ жағдайын талдау (Алакөл, Сасықкөл, Жалаңашкөл, Балхаш және Үшкөл көлдері мысалында)

Жетісу шөлді аймағында жайылымдардың өсімдік жамылғысы аз және олардың жемдік құндылығы өте төмен. Бұл жағдай құрғақ климатқа байланысты. Жауын-шашын мөлшері жылына 120-150 мм-ден аспайды, олардың көпшілігі күзгі-қысқы уақытта түседі. Жаз өте құрғақтықпен сипатталады, соңғы жылдары дамып келе жатқан аумақтың шөлейттенуі, топырақтың тұздану процестері шөлді жайылымдардың өнімділігін одан әрі төмендетеді. Бұл жағдайда шөлді аймақта орналасқан көлдердің жағалау белдеуінің өсімдік жамылғысы қызығушылық тудырады. Көлдердің жағалау белдеулері ылғалмен қамтамасыз етілген және өсімдіктері жақсы дамыған. Бірақ барлық жерде көлдердің жағалау аймағының өсімдіктері бірдей дамымайды және ол эдафикалық жағдайларға байланысты болады. Сондықтан шөлді аймақта орналасқан көлдердің жағалау белдеуінің топырағын зерттеу бізге өзекті болып көрінеді. Зерттеудің мақсаты – Жетісу шөлді аймағының тұзды және сода көлдерінің жағалау белдеуінің өсімдік жамылғысының өнімділігі мен жемшөп құндылығын арттыру үшін дамуының эдафикалық жағдайларын зерттеу. Зерттеу жүргізу үшін далалық (салыстырмалы-географиялық, картографиялық, маршруттық-барлау) және зертханалық зерттеу әдістері қолданылды. Алынған нәтижелер негізінде зерттелініп отырған аумақта сортаңданбаған топырақтар (Жалаңашкөл, Үшкөл көлдерінің жағалаулық топырақтары), аздаған сортаңды (Балқаш, Сасықкөл көлдерінің топырақтары) және жоғары

сортаңды (Алакөл көлінің жағалауының топырақтары) топырақтардың бар екені анықталды. Тұзданудың негізгі түрлері – сода-сульфатты және хлоридті-сульфатты. Алынған нәтижелер Жетісудың жер жамылғысын мониторингтік зерттеу және кешенді бағалау үшін негіз ретінде пайдаланылуы мүмкін. Зерттеу нәтижелері сонымен қатар тұздану жағдайында топырақ-өсімдік жамылғысының деградация дәрежесін бағалауға мүмкіндік береді.

Түйін сөздер: ақ сортаң батпақтар, тұзды батпақтар, агрохимиялық талдау, су сорғыш, жоғары – су және жағалау-су өсімдіктері, тұзды көлдер, сода көлдері.

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Анализ состояния почв прибрежной зоны соленых и содовых озер Жетысу (на примере озер Алаколь, Сасыкколь, Жаланашколь, Балхаш и Ушколь)

В пустынной зоне Жетысу растительный покров пастбищ скудный и кормовая ценность их очень низкая. Это происходит из-за сухости климата. Количество атмосферных осадков не превышает 120-150 мм в год, большинство которых выпадает в осенне-зимний период. Лето характеризуется чрезвычайной сухостью Развивающееся в последние годы опустынивание территории, процесс засоления почвы еще сильнее уменьшают продуктивность пустынных пастбищ. В качестве причин засоления на территории области выделяют первичные и вторичные факторы. К первичным относят участие материнской породы в формирование солевого статуса почвы, ко вторичным относят влияние антропогенной деятельности на почвенный покров: орошение водами с повышенным содержанием соли, складирование отходов, снега и т.д. В этих условиях представляет интерес растительный покров прибрежной полосы озер, расположенных в пустынной зоне. Прибрежные зоны озер обеспечены влагой и имеют более развитую растительность. Но не везде растительность прибрежной зоны озер развивается одинаково и зависит от эдафических условий. Поэтому изучение почв прибрежной полосы озер, расположенных в пустынной зоне, представляется нам актуальным. Целью исследования является изучение эдафических условий развития растительного покрова прибрежной зоны пустынь Жетысу для повышения их продуктивности и кормовой ценности. На основании полученных результатов выявлено, что на территории исследования присутствуют незасоленные почвы (почвы прибрежной береговой линии озер Жаланашколь, Ушколь), слабозасоленные (почвы озер Балхаш, Сасыкколь) и сильнозасоленные (почвы прибрежной зоны береговой линии Алаколь). Основным типом засоления являются содово-сульфатное и хлоридно-сульфатное. Полученные результаты могут быть использованы, как основа для мониторинговых исследований и комплексной оценки почвенного покрова Жетысуской области. Результаты исследования также позволят оценить степень деградированности растительного покрова в условиях засоления.

Ключевые слова: солончаки, солонцы, агрохимический анализ, водная вытяжка, высшие – водные и прибрежно-водные растения, соленые озера, содовые озера.

Introduction

The soil cover of Zhetysu has a number of features associated primarily with special climatic conditions: it's of continental climate type, saline, shows uneven distribution of precipitation, and has low soil moisture. This is due to the diversity of climate, its topography, underlying rocks, and vegetation. Most of the precipitation falls during the winter months. In the study area, zonal soils are gray soils, which are mainly of loamy and clay granulometric composition, often saline, with high pH and very low content of plant nutrients. The peculiarity of the structure of gray soils is due to the weak differentiation of genetic horizons, i.e. low content of organic matter and its complete mineralization [1].

Salinization of the soil cover and constant increase in its area from year to year due to poor drainage under the influence of both climatic conditions and anthropogenic activities are becoming one of the most urgent problems that lead to the degradation of soil cover, and a decrease in the biodiversity of plants and animals [2-4]. This problem directly affects the development of agriculture, the main task of which is to provide food for the population of the republic and feed for farm animals [5].

The soils of the study area can be classified as medium and highly saline. Soils with high salt content are inherent in steppe and desert landscapes,

however, soil salinization processes also occur in areas with humid climate, most often in the coastal zone, where inland water shows its influence through river channels and feeds through groundwater, which directly affects the salinization process of vast territories [6-9]. Primary and secondary factors that influence the accumulation of salts in the soil cover is distinguished as the causes of salinization in the region. The primary ones include the participation of the parent rock in the formation of soil salt status, the secondary ones include the influence of anthropogenic activities on the soil cover: irrigation with waters with high salt content, lack of drainage, waste storage, etc. [10].

The problem of soil salinity and vegetation cover degradation is devoted to a number of research works [6-8, 11-12], however, there is no complete information on the degree of salinization of the coastal zone of the Zhetysu region (Alakol, Sasykkol, Zhalanashkol, Balkhash and Ushkol).

Since at present the problems of soil salinization and degradation of vegetation cover are among the most urgent, the purpose of this research was to study the edaphic conditions for vegetation cover development of semi-aquatic lakes in the desert zone of Zhetysu to increase their productivity and fodder value.

Materials and methods

Fields (comparative geographic, cartographic, route reconnaissance) and laboratory research methods were used to make research [13-15].

Research objects. The objects of research were 5 survey points: soils of the semi-aquatic zone of Zhetysu lakes (it's the historical and geographical region of Kazakhstan, which includes the southeastern part of it, and consists of 7 main rivers, in the former Almaty region): Sasykkol, Alakol, Zhalanashkol, Balkhash and Ushkol (Figure 1).

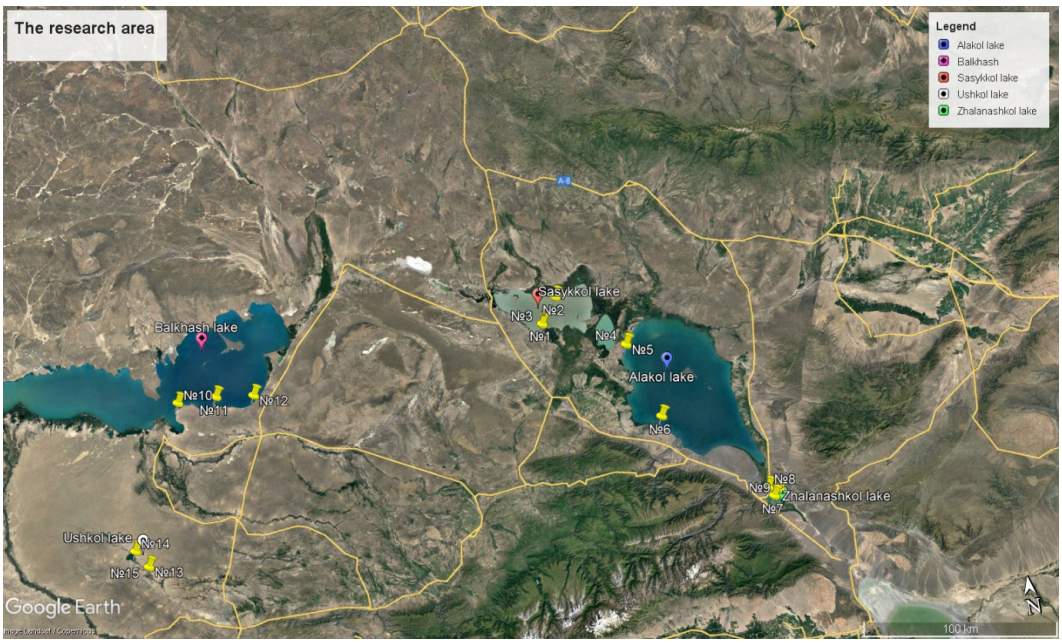

Figure 1 – The research area

Depending on the height above sea level, different natural areas formulate different conditions for soil formation processes. In the foothill plain, where the research objects are located, the climate is sharply continental, with hot summers and cold winters. Significant fluctuations in temperature are observed both between the seasons of the year and between the times of the day. The average January temperature in the plains is -15°C, in the foothills – 6-8°C; in July it is + 16 ° C and + 24-25 ° C, respectively, most of the precipitation falls in the winter months.

Lake Sasykkol occupies the northernmost position among the Alakol group of lakes, it is the second largest one and is characterized by a winding coastline. This is a shallow lake system with a uniformly regular hollow, elongated from east to west (Figure 2).

Figure 2 – Wormwood – mixed – grass community of Sasykkol lake

Lake Alakol is one of the largest salt lakes, and is the main one. Coastline of Alakol lake is highly rugged, forming numerous peninsulas, capes and bays. The vegetation is varied, with a predominance of *Phragmites communis, Typha angustifolia, Artemisia sp., Atriplex sp*. etc. (Figure 3).

Figure 3 – Saltwort – cattalis community of Alakol lake

Zhalanashkol is a lake located on the border of the Alakol district of Zhetysu and Urdzhar district of Abay region. According to its chemical composition, it belongs to the soda type: Na^+ and the sum of HCO_3^- + CO_3^{2-} are the first in the list of dominant ions (> 25e%). Relief is represented as a low-lying plain in the central part of the Balkhash-Alakol basin (Figure 4).

Figure 4 – Cattails-mixed-grass community of Zhalahashkol lake

Lake Balkhash is a semi-freshwater lake in a closed endorheic basin, which is located in the deepest part of the vast Balkhash – Alakol basin. The vegetation is saltwort, consisting of two tiers. The first forms are tree-shrub hodgepodges: kokpek, sarsazan, potash; the second is dominated by *Salicornia europaea., Suaeda prostrata, Karelinia caspia* etc. Most of the surface is bare, somewhere it is covered with salt (Figure 5).

Ushkol is a small brackish lake, which is located on a narrow semi-aquatic zone of clay-sand plain at the foot of Ushkara low-mountain range, in the interfluve of Karatal and Aksu. According to its chemical composition, it belongs to the soda type: Na^+ and the sum of HCO_3^- + CO_3^{2-} are the first ones in the list of dominant ions (> 25 e %) [16]. The shores of Ushkol are flat, clayey and sandy, with sparse vegetation characteristic of this soil type. The common representatives are *Tamarix ramosissima, Phragmites communis, Calamagrostis dubia* etc. (see Figure 6).

Research methodology. Soil sampling of 0.5 kg (3 replications at each site) was carried out in the summer of 2022 in accordance with GOST 17.4.4.02-84 “Nature Protection. Soils. Methods of sampling and samples preparation for chemical, bacteriological, helminthological analysis» at 5 points at a depth of 0-45 cm by using the «envelope» method.

The analysis of chemical composition was carried out by using the following equipment: laboratory type I-160 MI ionomer, flame photometer (FLAPHO-4 type), Specord 210 PLUS, electronic balances AR 2140 and ScoutProSPS202 F.

To determine the content of soluble salts in the soil and determine the type of salinity, water extract was used, which showed the content of organic and mineral water-soluble simple salts in the soil [17].

The type of salinity was determined by the sum of toxic salts, the chemistry type of salinity was determined by salinity degree, along with taking into account the «total effect» of toxic ions according to Bazilevich and Pankova’s method [18]. Mobile nitrogen was determined by the method of Tyurin and Kononova [19]. Mobile phosphorus and exchangeable potassium were determined by the method of G.V. Motuzova and O.S. Bezuglova (according to Kirsanov’s method) [20].

Figure 5 – Saltwort community of Balkhash Lake

Figure 6 – Cattails-mixed-grass community of Ushkol lake

The obtained data were statistically processed using MSExel and Statistics 6.0 application programs.

Results and Discussion

In the semi-aquatic zone of Sasykkol Lake, the soils are meadow-marsh, non-saline, medium loamy (Table 1). Soil samples were taken at points from the semi-aquatic lake zone according to these coordinates: 1.N 46 °29.287 ‘ E 80 °51.612 ‘, 2. N 46°34′321’ E 080°58.292’, 3. N 46 °29.021 ‘ E 080 °51.435 ‘.

According to the analysis of the water extract, the salt content is in the range of 0.107 – 0.504%. Salinization is observed at a depth of 15-30 cm to an average degree. The type of salinity is chloride-sulfate, the pH of the medium is 8.6, it is alkaline.

The soils of the semi-aquatic Alakol Lake zone are represented by meadow solonchak (saltmarsh) and ordinary medium loamy soils (Table 2). Soil sampling was taken from points of semi-aquatic zone according to the following coordinates: 4. N46°19.983’ E 81°22.541’, 5. N46°19.721’ E 081°22.402; 6. N45°59.073’ E 081°31.181’.

Table 1 – Results of water extraction of soil in the semi-aquatic zone of Sasykkol Lake

No.	Sampling depth, cm	Water/soil extract $\frac{\%\%}{m.eq}$ on completely dry soil									
		pH	The sum of salts, %	Alkalinity		Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
				The total in HCO_3	From normal carbonates to CO_3						
1	0 – 15	8.56	0.121	0.017	0.002	0.018	0.049	0.008	0.006	0.021	0.002
				0.28	0.08	0.51	1.03	0.39	0.49	0.90	0.04
	15-30	8.26	0.504	0.017	-	0.058	0.266	0.027	0.006	0.127	0.002
				0.28	-	1.64	5.54	1.37	0.49	5.54	0.05
	30 – 45	8.89	0.107	0.017	0.002	0.013	0.044	0.010	0.002	0.019	0.002
				0.28	0.08	0.36	0.92	0.49	0.20	0.84	0.04

Table 2 – Results of water extraction of soil in the semi-aquatic zone of Alakol Lake

No.	Sampling depth, cm	Water/soil extract $\frac{\%\%}{m.eq}$ on completely dry soil									
		pH	The sum of salts, %	Alkalinity		Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
				The total in HCO_3^-	From normal carbonates to CO_3						
2	0-15	9.98	3.215	0.163	0.067	0.452	1.519	0.002	0.010	1.051	0.018
				2.68	2.24	12.73	31.64	0.10	0.78	45.70	0.47
	15-30	10.29	0.876	0.085	0.034	0.090	0.414	0.004	0.004	0.276	0.002
				1.40	1.12	2.55	8.62	0.20	0.29	12.02	0.06
	30-45	9.23	0.918	0.024	0.005	0.393	0.197	0.039	0.065	0.177	0.021
				0.40	0.16	11.10	4.10	1.96	5.38	7.70	0.55

The maximum number of salts in the upper horizon is 3.215%, the type of salinization is soda-sulfate, the pH of the medium is 9.83, it is strongly alkaline. The lower horizons also have a high salt content (0.876 – 0.918%), the type of salinity is soda-sulfate and it is of soda-chloride type in the sample taken from deeper extraction. Wick salinization from saline groundwater is shown there from the deeper extraction points.

The soils of semi-aquatic Lake Zhalanashkol zone are meadow-marsh, non-saline, medium loamy (Table 3). Soil sampling was taken from the coastal line at the points with the following coordinates: 7. N45°32.197' E 082°84.557', 8. N45°34.946' E 082°06.979', 9. N 45 °33.487' E 082 °11.127 '.

According to the water extract analysis, the salt content lies within the range of 0.100 – 0.175%. The pH of the medium is 9.4, it is strongly alkaline. The largest amount of salts was found at a depth of 30-45 cm. The type of salinization is sulfate, and for the samples from deeper extraction the salinization is chloride-sulfate.

Table 3 – Results of water extraction of soil in the semi-aquatic zone of Zhalanashkol Lake

No.	Sampling depth, cm	Water/soil extract $\frac{\%\%}{m.eq}$ on completely dry soil									
		pH	The sum of salts, %	Alkalinity		Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
				The total in HCO_3^-	From normal carbonates to CO_3						
3	0-15	9.48	0.113	0.041	0.007	0.005	0.032	0.002	0.002	0.025	0.004
				0.68	0.24	0.15	0.67	0.10	0.20	1.10	0.11
	15-30	9.67	0.100	0.037	0.007	0.003	0.033	0.002	0.004	0.021	0.002
				0.60	0.24	0.07	0.68	0.10	0.29	0.90	0.06
	30-45	9.09	0.175	0.063	0.007	0.006	0.053	0.004	0.005	0.035	0.008
				1.04	0.24	0.18	1.11	0.20	0.39	1.54	0.20

The soils of the semi-aquatic Balkhash Lake zone are desert sands with characteristics of humus content, they are carbonate, slightly fixed and hilly (Table 4). Soil samples were taken from points of semi-aquatic lake zones according to the following coordinates: 10. N 46°22.986' E 078°25.209', 11. N 46°23.236' E 078°40.477', 12. N 46 °22.178' E 078 °55.329'.

The number of salts, according to water extract results, varies from 0.03 to 0.161%. The maximum amount is found in the upper line at a depth of 0 – 15 cm, it is 0.161%. The pH of the medium is 9.23, that is an indicator of very strong alkalization. The type of salinity is chloride-sulfate, in the lower layers it is a chloride one.

Table 4 – Results of water extraction of soil in the semi-aquatic zone of Balkhash Lake

No.	Sampling depth, cm	Water/soil extract $\frac{\%\%}{m.eq}$ on completely dry soil									
		pH	The sum of salts, %	Alkalinity		Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
				The total in HCO_3^-	From normal carbonates to CO_3						
4	0 – 15	8.06	0.161	0.032	0.002	0.021	0.060	0.010	0.005	0.033	0.002
				0.52	0.08	0.58	1.25	0.49	0.39	1.43	0.04
	15 – 30	9.53	0.030	0.020	0.002	0.003	0.000	0.004	0.001	0.002	0.001
				0.32	0.08	0.07	0.00	0.20	0.10	0.07	0.03
	30 – 45	9.6	0.035	0.017	0.002	0.001	0.008	0.004	0.002	0.001	0.002
				0.28	0.08	0.04	0.17	0.20	0.20	0.05	0.04

The soils of the semi-aquatic Lake Ushkol zone are represented by non-saline desert sands having some humus content, they are carbonate and flat (Table 5). Soil samples were taken from points of semi-aquatic lake zone according to the following coordinates: 13. N 45 °39.968 ‘ E 078 °04.831 ‘, 14.N 45 °44.604 ‘, E 078 °00.388’, 15.N 45 °39.724 ‘ E078°04.641’.

Table 5 – Results of water extraction of soil in the semi-aquatic zone of Ushkol Lake

No.	Sampling depth, cm	Water/soil extracton %% / m.eq completely dry soil									
		pH	The sum of salts, %	Alkalinity		Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
				The total in HCO_3^-	From normal carbonates to CO_3						
5	0-15	8.85	0.108	0.027	0.001	0.008	0.042	0.006	0.004	0.021	0.001
				0.44	0.04	0.22	0.87	0.29	0.29	0.92	0.03
	15-30	8.52	0.159	0.029	0.001	0.017	0.065	0.010	0.005	0.032	0.001
				0.48	0.04	0.47	1.35	0.49	0.39	1.40	0.03
	30-45	9.6	0.085	0.024	0.002	0.009	0.026	0.004	0.002	0.018	0.002
				0.40	0.08	0.25	0.55	0.20	0.20	0.77	0.04

According to water extract results for soil samples taken from different levels, an insignificant salt content of 0.08-0.15% was found. The pH of the medium is 9, it is strongly alkaline. The type of salinity is chloride-sulfate with the presence of soda.

Also, the content of mobile nutrients (MFN) is one of the main indicators of good soil fertility. For the growth and nutrition of plants, the most important role belongs to 3 elements: nitrogen, phosphorus and potassium.

According to the agrochemical analysis results of the soil in the semi-aquatic zone of salt and soda Zhetysu lakes, presented in Figure 7, the soil composition degree of mobile elements was assessed.

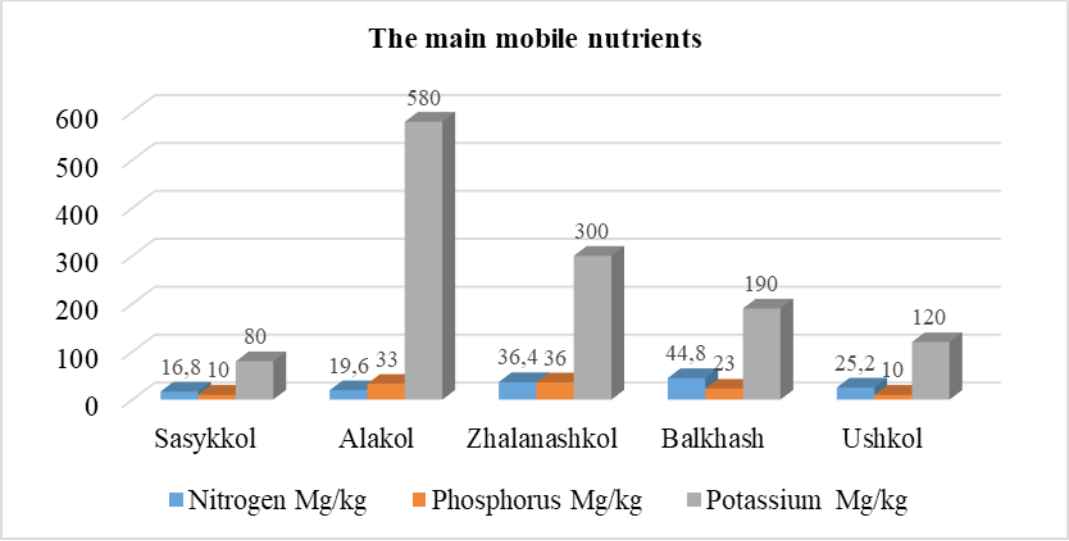

Figure 7 – Mobile nutrients of the semi-aquatic zone of saline and soda lakes of Zhetysu

The semi-aquatic soil downstream of the lakes was shown to have following numbers of mobile nitrogen: Sasykkol shows 16.8 mg/kg, Alakol shows 19.6 mg/kg, Ushkol shows 25.2 mg/kg, that indicate a very low degree of availability of soluble nitrogen (< 30). The content of mobile nitrogen in Balkhash (44.8 mg/kg) and Zhalanashkol (36.4 mg/kg) lakes allows one to consider the soil as having a low degree of availability. Thus, it is possible to divide the soil into 2 groups:a group of soils with a very low degree of availability of mobile nitrogen and with a low content (presented on Figure 8).

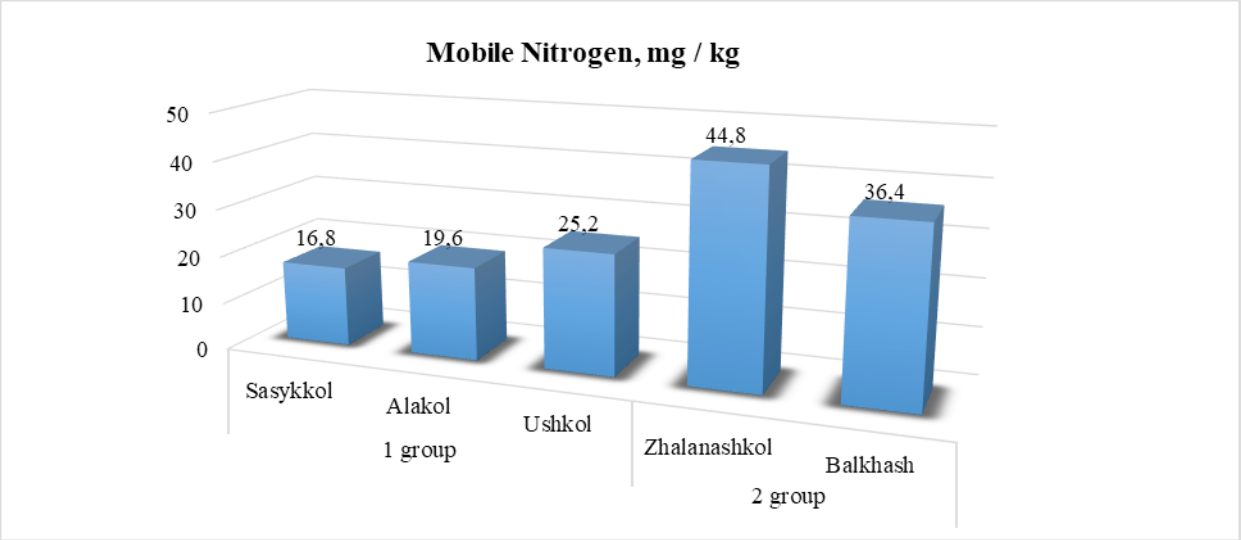

Figure 8 – The content of mobile nitrogen in soil samples of the semi-aquatic zone of saline and soda lakes of Zhetysu

According to the content of mobile phosphorus, semi-aquatic soils of studied Zhetysu lakes can be divided into 3 groups:

Group I: the degree of availability of mobile phosphorus is very low (<10), semi-aquatic soil of Sasykkol and Ushkol lakes (10 mg/kg) belong to this group.

Group III: medium availability of mobile phosphorus (16-30 mg/kg), semi-aquatic soil of Balkhash Lake (23 mg/kg) belongs to this group.

Group IV: increased availability of mobile phosphorus (31-45 mg/kg), semi-aquatic soil of Alakol (33 mg/kg), Zhalanashkol (36 mg/kg) lakes belong to this group, see Figure 9.

According to the content of exchangeable potassium, semi-aquatic coastal soils of salt and soda Zhetysu lakes belong to 4 groups: with very low supply, low, medium and high.

Group I includes semi-aquatic coastal soil of Sasykkol Lake, with an exchangeable K content of 80 mg/kg, and it shows a very low availability degree (<10 0). Group II includes the soils of lakes Ushkol (120 mg/kg) and Balkhash (190 mg/kg): these indicate low degree of availability (101-200). Group III includes semi-aquatic coastal soil of Zhalanashkol Lake (300 mg/kg): it shows medium degree of availability (201-300). Group IV shows high availability degree of exchangeable potassium (401-600), it includes semi-aquatic coastal soil of Alakol Lake of 580 mg/kg (see Figure 10).

Thus, according to the obtained data of agrochemical analysis, the most fertile soils can be attributed to the semi-aquatic lines of Alakol and Zhalanashkol lakes. It was shown during the research that there is a higher content of mobile phosphorus, potassium and nitrogen in the soil composition (with the exception of Alakol soils).

Soil salinization is a global problem that has an adverse impact not only to the vegetation cover, but also on agriculture in general. This problem is researched and investigated in both foreign studies [21], where they present and discuss the most optimal solutions [22-23], and local ones [6-8], which provide information on soil condition and the degree of their degradation.

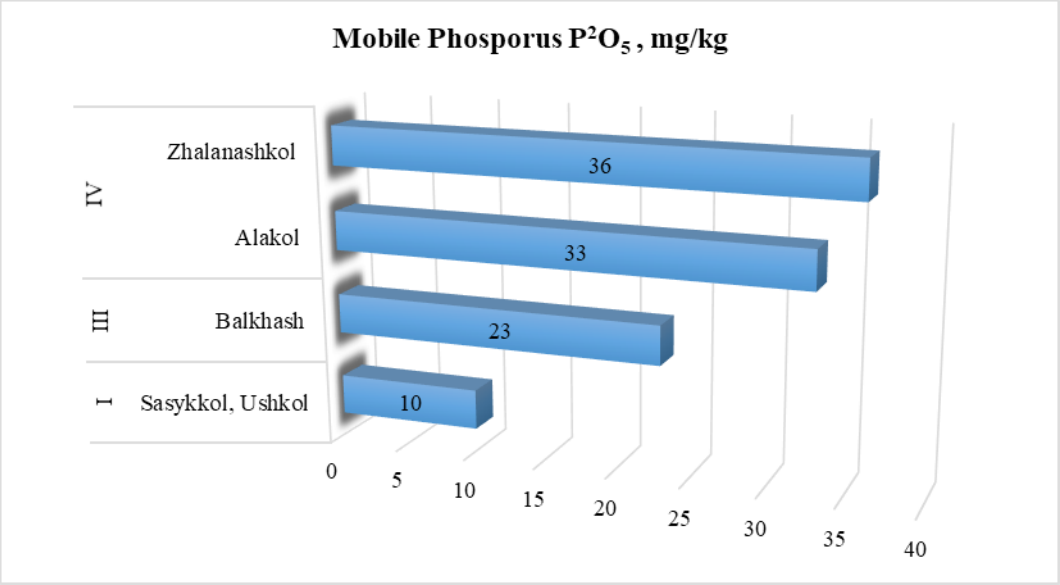

Figure 9 –The content of mobile phosphorus in soil samples of the semi-aquatic zone of saline and soda lakes of Zhetysu

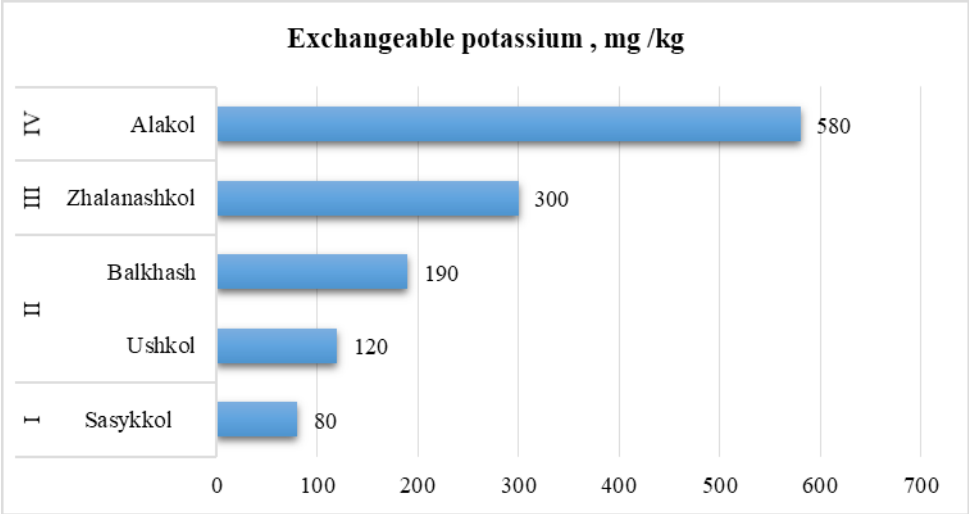

Figure 10 – The content of exchangeable potassium in the soils of the semi-aquatic zone of saline and soda Zhetysu lakes

Soil salinity inhibits plant growth and development with adverse effects such as osmotic stress, Na^+ and Cl^- toxicity, ethylene production, plasmolysis, nutrient imbalance, reactive oxygen species (ROS) production, and disruption of photosynthesis [24]. According to the literature data, soil content of more than 0.25% indicates the inhibition of the vegetation cover [25]. Water extract data demonstrate different degrees of soil salinization in the semi-aquatic coastal zone of salt and soda Zhetysu lakes. The same amount of salts, depending on their composition, may also indicate a different degree of soil salinity, which is due to the unequal toxicity of various easily soluble salts for plants.

Alakol soil shows high salinity degree, the amount of salts varies between 3.215-0.876%. This type of soil is characterized by strong inhibition of

vegetation, and very often only single representatives of weed species and halophytes (*Salsola dendroides, Salicornia europaea, Tamarix ramosissima*) are able to grow on such a soil. Salts show toxic effects on plants, disrupt metabolism, make it difficult for plants to absorb nutrients from the soil, are a cause of a decrease in yield and deterioration in the fodder quality of grass cover. The projective cover was 30-40% on the territory of checked and surveyed points of No. 4,5,6. The dominant communities are reed and saltwort. The soils of the semi-aquatic wetland coastline of Balkhash Lake belong to the moderately saline degree; they are characterized by an average degree of inhibition of plants vital processes. However, it is necessary to take into account sandy mechanical composition, which is poorly absorbed by salts and is characterized by a specific type of vegetation (the representatives are *Haloxylon aphyllum*, *Calligonum aphyllum* etc.). The projective cover was 40-50% in the survey area (points No. 10-12), the dominant communities are saltwort and shrub-forb with a predominance of *Calligonum aphyllum, Tamarix ramosissima.*

Non-saline soils include a semi-aquatic coastline of Sasykkol, Zhalanashkol and Ushkol lakes, where the amount of salts does not exceed 0.25% and it is favorable for plant growth. The projective cover is 70-80%. Dominant communities include reed-forb with predominance of *Phragmites sp.* and grass-forb with predominance of *Agropyron sp*.

It should be noted that pH of the medium in all samples is > 7; The soil is alkaline and strongly alkaline. Soil alkalization is caused by an excess of anions such as CO_3^{2-} and Na^+ cations in the soil solution. For the vital activity of plants (growth and development), the most optimal pH range is 5.5-8. Alkalinity reduces soil fertility and disrupts the physiological balance of ions, which in turn leads to deterioration and worsening in plant nutrition, violation of carbohydrate, protein and phosphorus metabolism. Sasykkol and Ushkol lakes are less fertile. The lack of nutrients negatively affects growth and development of plants: with a lack of phosphorus, plant growth slows down, which, of course, cannot but affect the yield; lack of nitrogen disrupts the process of photosynthesis, due to the destruction of chlorophyll, drying and necrosis of plant parts is possible; sufficient content of potassium in the soil increases plants resistance to the effects of low and high temperatures, diseases, and it also reduces the time of plant maturation. Complex fertilizers containing several nutrients are used to compensate for the lack of nitrogen, phosphorus and potassium in the soil. For example, it is ammoniated superphosphate, ammophos, diammophos, potassium nitrate.

Conclusion

Thus, as a result of the research, it was revealed that edaphic conditions directly affect vegetation development cover of semi-aquatic coastline of salt and soda Zhetysu lakes. It was revealed that there are non-saline soils (soils of semi-aquatic coastline of Zhalanashkol, Ushkol lakes), slightly saline (soils of Balkhash, Sasykkol lakes) and highly saline (soils of the semi-aquatic coastline of Alakol Lake) in the study area. According to the chemistry of salinization, soda-sulfate and chloride-sulfate types prevail there.

Soil salinization has the following negative consequences: many species of plant organisms disappear, while new halophyte plants (*Salsola dendroides, Salicornia europaea, Tamarix ramosissima* etc.) appear, the gene pool of terrestrial populations is decreasing due to the deterioration of living conditions of organisms, and migration processes are being intensified.

At present, salinity and alkalinity of semi-aquatic soils of Zhetysu lakes cause decrease in the productivity and quality of pasture lands. To increase soil fertility, it is necessary to compensate for the lack of basic mobile nutrients by using complex fertilizers containing several nutrients at once.

Restoration of saline soils, especially highly saline soils, is possible only with complex land reclamation measures. At present, the most promising one is a complex technology for restoring the properties of technogenically saline and alkaline soils, which include introduction of various ameliorants, phytomelioration processes, and the use of biological preparations.

Conflict of interest

All authors have read and are familiar with the content of the article and have no conflict of interest.

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