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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.

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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 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

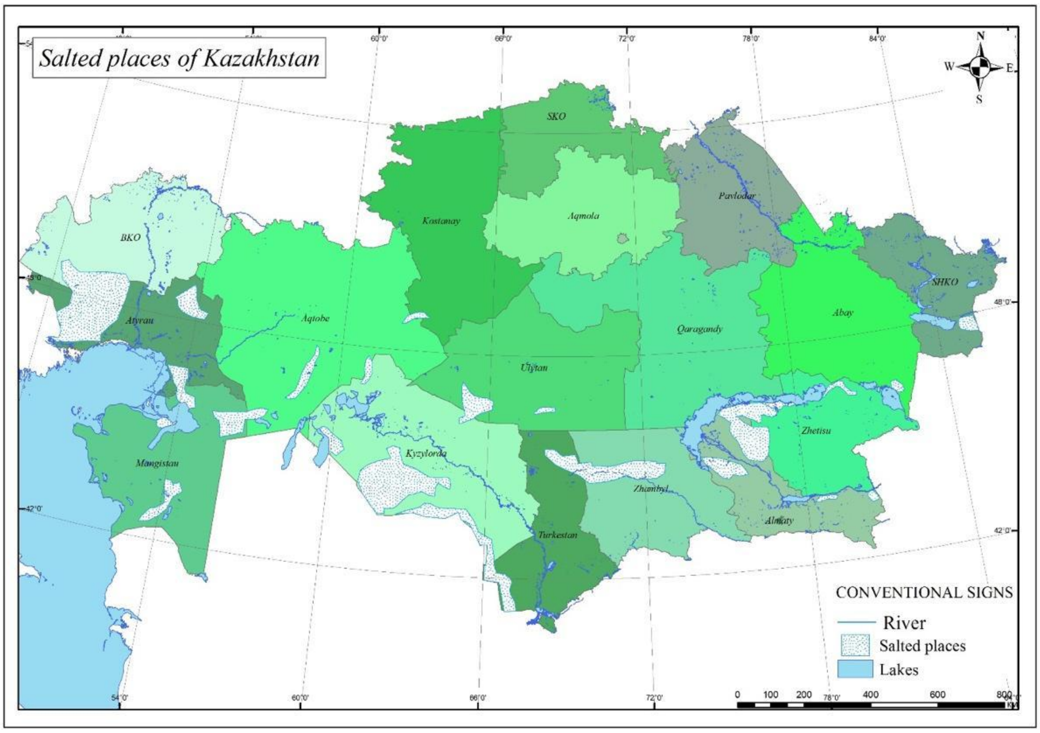

Figure 1. Map of saline areas of Kazakhstan

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 Discussion

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.

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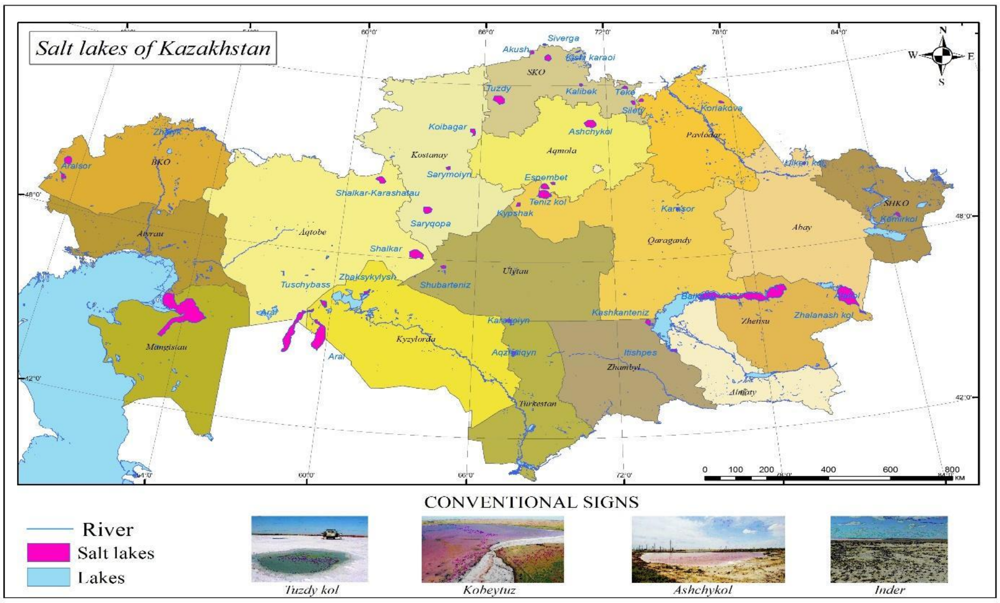

Figure 2. Map of salt lakes in Kazakhstan

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 Maraldy is a salt lake known worldwide for its medicinal clay. As a result of research of dry residue of soil near Maraldy 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–:SO42– — 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

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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.

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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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