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DESERTIFICATION AND LAND DEGRADATION IN KAZAKHSTAN

Abstract. Desertification and land degradation are common processes in arid and semi-arid regions of Kazakhstan, especially southern parts, where areas are covered by a great variety of desert types. In deserts, soil-forming processes take place in conditions of severe water shortage, and high level of soil degradation and desertification. The main natural factors for these processes are a flat terrain, a high degree of arid climate, soil salinity, carbonate content, a lack of structure and low natural soil fertility. However, the anthropogenic factors of desertification and soil degradation became dominant last decades.

The study considers the actual problems of natural and anthropogenic factors of desertification and land degradation within Kazakhstan. The desertification of huge territories is accompanied by soil contamination, waterlogging by surface water and groundwater, soil salinization, erosion (water, wind), degradation of vegetation cover, dehumidification and a decrease in general regional biological capacity. Analysis of the current status of the soil cover has shown intensive land degradation 43 % of the territory of Kazakhstan is subjected to degradation in significant degree; over 14 % of pastures have reached an extreme degree of degradation or are completely degraded. The Aral Sea region, Northern Caspian Sea and Southern Balkhash deserts can be observed as areas of intensive soil desertification, salinization and deflation processes. As well as the desertification process are progressing in the irrigated soils of the deltas of Syrdarya, Shu, Ile and Karatal rivers.

Key words: soil degradation, desertification, arid region, Kazakhstan.

Introduction. Desertification is one of the unsolved environmental problems affecting a large part of Kazakhstan and the world. More than two thirds of the territory in Kazakhstan is subject to desertification [1]. Desertification is a complex process as ecosystem depletion, loss of soil fertility and its biological productivity and land degradation in general. The process is promoted by the ecological instability of natural landscapes and anthropogenic overloads. In Kazakhstan, natural and anthropogenic desertification processes take a large area. Natural deserts in Kazakhstan are distinguished by a wide strip to the south of 48 ° N, and bordered with chestnut steppe soils from thenorth, in the south and east, they border on the piedmont plains of Tien Shan, Zhetysu (Djungar) Alatau, Sauyr-Tarbagatai and Altai Mts. Deserts are the most arid regions of Kazakhstan. In deserts, soil-forming processes take place in conditions of severe water shortage, and high level of soil degradation and desertification. The main natural reasons for these processes are a flat terrain, a high degree of arid climate, soil salinity, xero-halophytic vegetation, widespread brown calcareous saline and structureless soils, which are characterized by low natural soil fertility [2].

Natural semi-desert and desert zones occupy almost 70% of the territory in Kazakhstan. Significant areas are covered by sand (32 million hectares), solonchaks (2.6 million hectares) and flat plains with takyr (0.3 million hectares) [1]. A large area in Kazakhstan are subject to desertification that is 120 million hectares of deserts and 180 million hectares of desertification by anthropogenic factors [3].

The active development of natural resources and infrastructure of the mining and processing industries has led to the loss of stability of fragile ecosystems of arid territories in Kazakhstan. Anthropogenic impact during the construction and laying of roads, pipelines, power lines, open mining of minerals contributed to the change of relief environment, degradation and destruction of the soil and vegetation covers of large areas with direct impact. An indirect impact of anthropogenic interference was the intensification of soil deflation, erosion, soil salinization. A more serious cause of desertification was pollution of deposit's territories, transportation places and processing of hydrocarbon raw materials with oil products and radioactive compounds in petrochemical effects.

Study area. Kazakhstan is one of the rapidly developing and youngest independent countries in the world. It lies between the Siberian Taiga in the north and the Central Asia deserts in the south, the Caspian Sea in the west and the mountain range of the Tien-Shan and Altay in the east [4]. About 60 % of Kazakhstan is flat lands. Deserts and semi-deserts occupy approximately 50 % of the territory, most of them situated in the Turan plain. Arid territories spread from Caspian Sea to foothill plains of Zhetysu (Zhongar) Alatau and Tien-Shan mountains. These vast territories have various geological structure and landscape features such as sandy deserts: Naryn, Kyzylkum, Pre-Aral Karakum, Moiynkum, Saryesikatyrau. The northern parts of Kazakhstan are steppes and forest-steppes [5, 6]. Kazakhstan's climate is a sharp continental with uneven distribution of precipitations within the territory. Plain areas are generally dry and have precipitation from 100 mm in the southwest up to 400 mm annually in the north. In the plains the saline soils are distributed widely. In the mountainous regions, the precipitation ranges between 400 mm and 1600 mm [7, 8]. Average temperature is -18 °C in January in the north and -3 °C in the south. Average temperature in July increases gradually from 19 °C in the north up to 28-30 °C in the south.

Materials and Methods. The Arc map software was used as the main tool to assess and analyze the current state of the soil cover in Kazakhstan as well as for preparing the map of soil degradation and desertification within Kazakhstan.

The original map from NAKZ [1] with the border of soil degradation and desertification was scanned and registered/geo-referenced to specify its location by using vector layer of country's border. Thereafter, the collected data on soil pollution types, transformation, and types of ecological changes in soil were given as input parameters for the generation of maps using ArcGIS applications.

Results and Discussion. Review on land degradation and desertification processes. The main factors of the soil degradation are soil salinization, soil erosion (wind/water erosion), dehumification processes, soil deflation, and reduction in the productivity of arable lands (figs. 1-2). Analysis of the current status of the soil cover has shown intensive land degradation and desertification processes. According to the data of the Agency on Land Resources Management, more than 75 % of the territory of Kazakhstan is subjected to degradation and desertification; over 14 % of pastures have reached an extreme degree of degradation or are completely degraded. In the regional environmental case, in northern Kazakhstan on chernozems and dark chestnut soils the dehumification processes are progressing and as a result, soil erosion, deflation and reduced productivity of arable land. The ecological crisis in the Aral Sea region remains as the main problem in Southern Kazakhstan [9]. The area is subjected to irreversible processes of desertification. In the most fertile delta-alluvial plain of Syrdarya riveris the main rice granary of the country, as well as the Balkhash-Alakol region is widely noted processes of secondary soil salinization of irrigated lands and destruction; land erosion and digression is occurring in foothill and mountain areas. In the most fertile delta-alluvial plain of the Syrdarya river, the area of desertified land is 1.1 mln ha, and in the dried -up bottom of Aral Sea it is 1.5 mln ha, of which saline march soils occupy 0.8 mln ha. In contrast to other natural zones, these vast areas are occupied by sand (17.5 mln ha), saline soils (2.6 mln ha) and takyr plains (0.3 mln ha). The total are of saline soils in the desert zone with brown and grey-brown soils exceeds 60 mln ha, and alkaline complexes are present in 22 mln ha [10]. On the vast territory of Kazakhstan, there are a number of regions where the combination of various forms of environmentally damaged soils has resulted in a crisis situation. Disastrous environmental conditions can be observed in the Aral Sea region: zones of intensive soil desertification, salinization and deflation [11,12]. The regions of Central and East Kazakhstan, which are the major industrial centers, are involved to technogenic disturbances and the industrial pollution of soils with toxic chemical and radio active

elements. Every year, about 3-4 mln tones of polluting chemicals are emitted to the atmosphere or deposited on the soil surface. The region is characterized by radioactive pollution and man-made destruction of the soil cover in the test sites of nuclear missiles, mining and processing mineral resources. In the oil and gas regions of western Kazakhstan and Torgay plain created large pockets oil and radioactive contamination of soil, soil salinization by wastewaters, and industrial transformation of the soil cover.

Main degraded regions within Kazakhstan. The influence of anthropogenic factors is seen almost in all natural landscapes, especially in the Aral Sea region, where degradation and desertification processes are becoming more widespread. Additionally, the northern Caspian Sea and southern Balkhash deserts belong to significant and high degree of Land degradation under the influence of grazing [13]. Pasture degradation touched mostly desert and semi-desert landscapes in Kazakhstan. The desertification of large territories is accompanied by soil salinity, dehumidification, soil erosion, deflation, soil contamination, waterlogging by surface water and groundwater and a decrease in general regional biological capacity as well as reduced productivity of arable land. In addition, desertification largely includes economic (agricultural land productivity) and social (poverty, migration) problems.

Soil salinization and soil erosion (wind/water erosion). Soil salinization widely and commonly manifests in all areas of natural zones and it is associated with poor drainage of the territory, the initial salinity of the lake-marine and alluvial-deltaic parent rocks and mineralized groundwater. The problems of soil salinity are most widespread in the arid and semi-arid regions but salt affected soils also occur extensively in sub-humid and humid climates, particularly in the coastal regions where the ingress of sea water through estuaries and rivers and through groundwater causes large-scale salinization [14-16]. The soil salinity is also a serious problem in areas where groundwater of high salt content is used for irrigation [17].

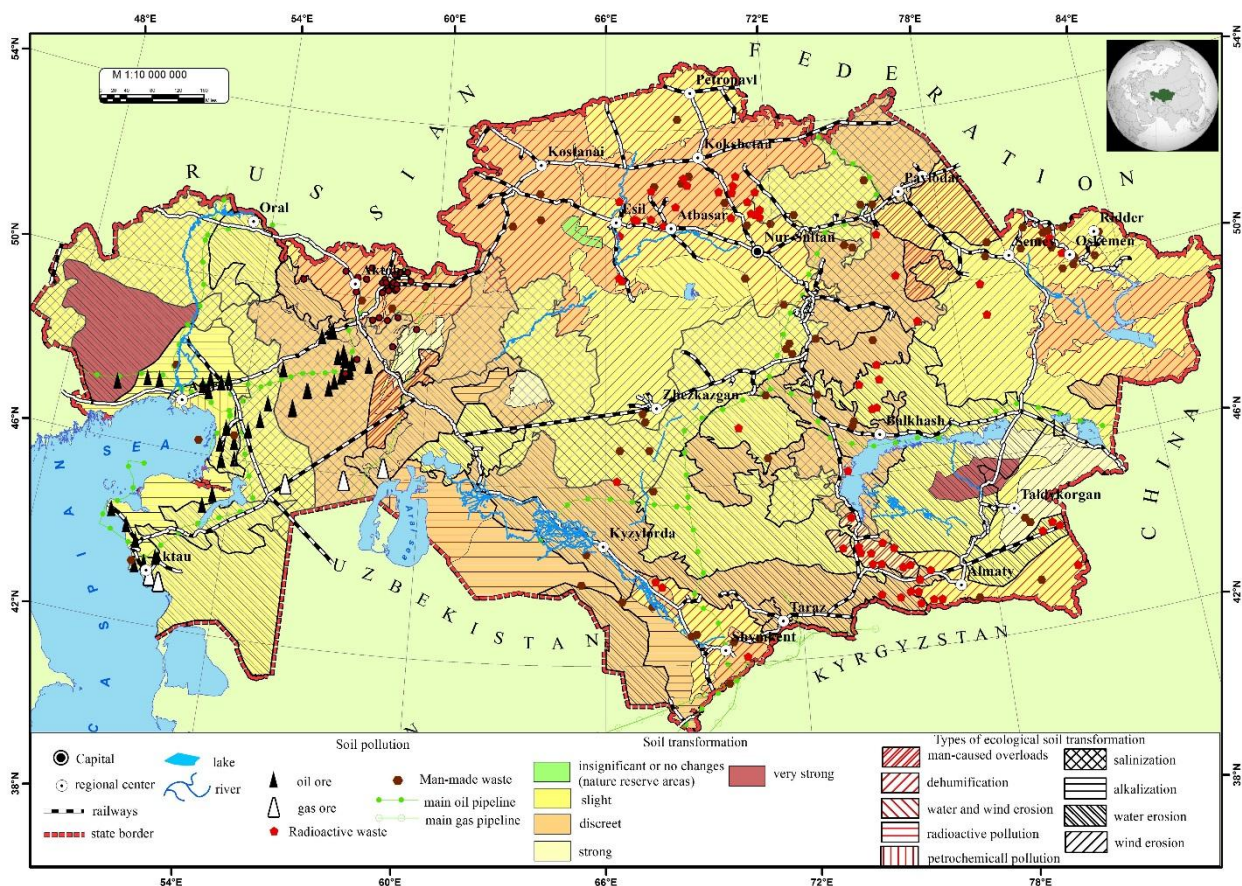


Figure 1 – Soil degradation and desertification map of Kazakhstan

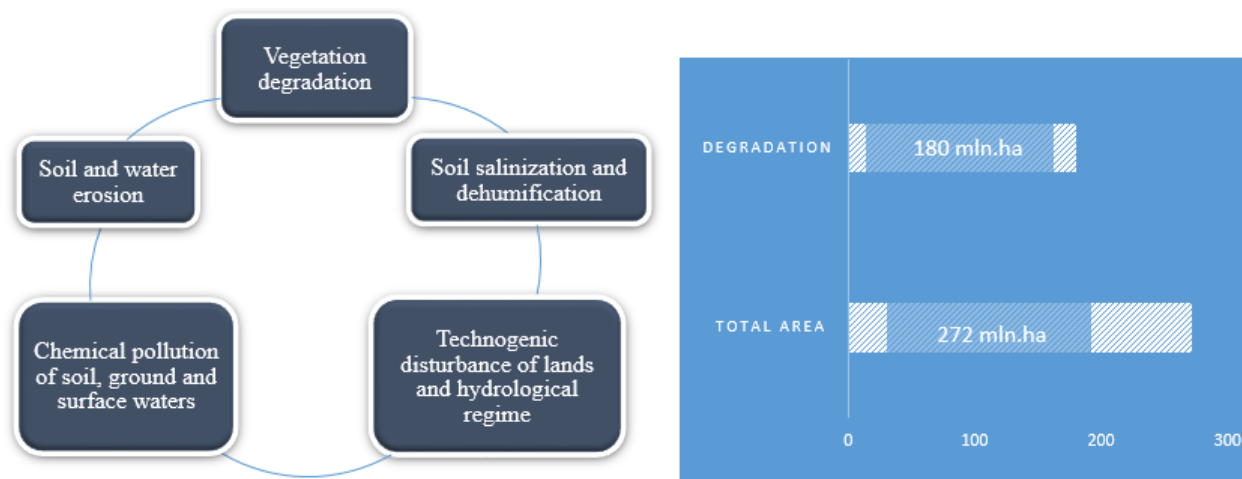


Figure 2 – The main factors of the desertification

A saline soil is an indispensable component of steppe and desert landscapes [18]. They are widespread in arid and semi-arid regions of the world. According to the data of International Institute for Environment and Development and World Resources Institute about 10 % of the surface of continents covered by saline soils. They are mostly distributed in arid lands, as well as zones of dry and desert steppes [15,17]. The saline soil is defined as having a high toxic concentration (0.25 %) of soluble salts in any soil profile to affect plant growth [19].

The saline soils mostly distributed in Central Asia and Kazakhstan, including West Siberia, West China. The most part of saline soils (70%) in the CIS countries occurred in Kazakhstan. Numerous reports were done about origin, development, conditions of saline soil formation in the territory of Kazakhstan [18,20-21]. Saline soils are widely distributed in the southern and central parts of the Kazakhstan [22]. In these arid regions, where rainfall is 100-150 mm y⁻¹ and evaporation exceeds precipitation. Saline soils are soils that contain high concentrations of soluble salts: sodium, magnesium and calcium sulphates, and some sodium chloride, but have normal pH values [11,18].

On the territory of Kazakhstan allocated four salt accumulation provinces: sulphate-chloride basin of the Caspian Sea, chloride-sulphate basin of the Aral Sea, soda-sulfate basin of the Balkhash Lake and chloride-sulfate basin of the Kara Sea [18]. Each province has an own type of salinity and chemical features and differ in their genesis, composition and transport of salts. Depending on the chemical composition and the amount of soluble salts in the profile there are following degree of soil salinity: the amount of salt is 0.1-0.3 % in slightly saline soils, moderately saline is 0.3-0.5 %, strongly saline is 0.5-1.0 %, solonchanks more than 1.0 % [23].

The soil salinization is one of the most common land degradation and desertification processes. Anthropogenic stress to soil cover and ecosystem in Kazakhstan year by year increasing in the all geographical zones. Irrational use of the natural resources leads to ecological violation. The total area of Kazakhstan is 272 million hectares, at present day 180 million hectares is under the danger of degradation, or 60 % of the total territory [10,22].

Soil erosion (wind/water erosion) appear in all natural zones, but is particularly strong in the long-term arable land, sand massifs, as well as in mountain and foothill areas [8,24]. Development of wind erosion is due to soils with light-textured, carbonate, structureless of soils and intensity of anthropogenic pressure. The anthropogenic pressure increased in the sandy deserts of southern Pre-Balkhash region, Aral Sea and Northern Caspian Sea regions. As a result, sources of soil deflation appeared in these regions that lead to high concentration salts in the atmospheric flows. These salts provoke deterioration of pastures, reduction of biodiversity, salinization and desertification of soils [10]. Protection against to soil erosion and destruction requires erosion reclamation (agrotechnical, biological, chemical).

Dehumidification and soil contamination. Ecological state of the soil cover in many areas of Kazakhstan is characterized by near-critical and requires urgent measures of fertility reproduction and preservation of the environment.

Dehumidification takes place on chernozems and dark chestnut soils with long-term non-irrigated arable land in the northern regions of Kazakhstan and as well as the mountainous regions of irrigated arable land [24]. Monoculture cultivation of grain and industrial crops on low agrotechnical conditions causes of dehumidification process and loss of soil fertility by 20-30 % and southern chernozems on virgin soil is 4.5-5.5%, long-term arable land by 3.0-3.5 %, dark chestnut soil is 3.5-4.4 and 3.0-3.3 % [13]. Micro aggregation of soil deteriorate in cultivated soils, there is a real risk of suffering from water and wind erosion, which requires immediate action for the conservation and restoration of soil fertility (organic and mineral fertilizers, minimizing the processing, the introduction of grass crop rotation, planting trees, bushes and shrubs). According to the map of the soil dehumidification the loss of humus up to 5 % is weak degree of it, moderate is 5-10 %, a strong and very strong is 10-15 %, 15-20 % respectively [23].

Soil contamination (chemical, petrochemical, radioactive) is reflected in the areas of industrial, oil and gas, as well as of landfill testing of nuclear missiles. Chemical contamination of individual regions occurs among the arable chernozems and dark chestnut soils, irrigated soils in the south part of Kazakhstan [24] under the immoderate use of organic and mineral fertilizers, pesticides, herbicides and other, which lead to the accumulation of toxicants in soils [25]. According to the toxicity, the arsenic, cadmium, mercury, selenium, lead, zinc, fluorine are high toxic elements; moderately dangerous is cobalt, boron, nickel, molybdenum, copper, chromium and barium, strontium, tungsten, manganese belong to low risk. Decomposition and detoxification of chemical elements in the soil profile is due to the pH of the medium, mechanical, mineralogical composition, temperature, humidity, intensity of microbiological processes.

Petrochemical contamination of soil is allocated in all areas of oil and gas companies and routes of the oil/gas pipelines in Western Kazakhstan. The contamination occurs at all stages of field development.

Radioactive contamination of soil occurs in the places allocated former test radioactive sites (Semei, Kapustin Yar, Pribalkashe et al.), as well as in the areas of oil and gas complex such as Ozen-Zhetybai, Bozashy, Karachyganak.

Conclusion. The desertification and land degradation of large territories is accompanied by soil salinity, dehumidification, soil erosion, deflation, soil contamination, waterlogging by surface water and groundwater and a decrease in general regional biological capacity as well as reduced productivity of arable land.

The Aral Sea region, Northern Caspian Sea and Southern Balkhash deserts can be observed as areas of intensive soil desertification, salinization and deflation processes. As well as the desertification process are progressing in the irrigated soils of the deltas of Syrdarya, Shu, Ile and Karatal rivers. In Kazakhstan apart from natural environmental factors, the anthropogenic pressure increased their effect seriously during the last 50 years. All these actions destroy seriously the environmental processes and led to the serious forms of rapid soil/land degradation and desertification processes. The influence of anthropogenic factors is seen almost in all natural landscapes, especially in the Aral Sea region, where degradation and desertification processes are becoming more widespread.

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ҚАЗАҚСТАН ЖЕРІНІҢ ШӨЛЕЙТТЕНУІ ЖӘНЕ ДЕГРАДАЦИЯҒА ҰШЫРАУЫ

Аннотация. Жер деградациясы мәселесі дүниежүзімен коса, Қазақстанда да өзекті. Деградацияға ұшыраған жерді игеру мәселесін зерттеуге ерекше көңіл бөлінеді. Жердің шөлейттенуі және деградацияға ұшырауы Қазақстанның құрғақ және жартылай құрғақ аудандарында, әсіресе, алуан түрлі шөл басым оңтүстік аудандарда қалыпты жағдай болып саналады. Шөлде топырақ түзілу үрдістері су жетіспегенде, топырақ жоғарғы деңгейде деградацияға ұшырағанда және шөлейттенгенде жүре бастайды. Бұл үрдістердің негізгі табиғи факторлары – сол жердің жазық болуы, жоғары дәрежедегі климат құрғақшылығы, топырақ тұздылығы мен құрылымсыздығы, карбонатты құба топырақтың кең таралуы және төмен табиғи құнарлылығы. Алайда кейінгі онжылдықта шөлейттенудің антропогенді факторы мен топырақ деградациясы басым болғандықтан, елдің аграрлық саласының дамуына да әсер етуде.

Деградация үдерісі топырақтың құнарлылығы мен өнімділігін төмендетеді және сәйкесінше топырақ жамылғысына, тұтастай ауылшаруашылық секторына кері әсер етеді. Барлық егіс алқабында гумустың жоғалғандығы байқалады, ал суарылмайтын егіс алқабы 11,2 млн га құрғақшылық салдарынан шөлейттенеді, суармалы егістік жерлер – 0,7 млн га, суармалы егістік жер (31,3%) топырағының үштен бірі дерлік сортаңданған және олар тұзды шөлді көбейтеді. Сонымен қатар, Сырдария, Шу, Іле және Қаратал өзендерінің суармалы топырағы да шөлдене бастады.

Қазақстанда бүкіл аумақтың 280 миллионының 165 миллион гектары шөл және жартылай шөл зоналарына жатады. Табиғи жартылай шөл және шөлейттену зоналары Қазақстан территориясының 70% алып жатыр. Бұл негізінен оңтүстік және батыс аймаққа тән, ондағы топырақ шөлейттенуге бейім және құмды массивті (32 млн. га), сортаң (2,6 млн. га), тақыр жазық (0,3 млн. га) болып келеді.

Зерттеуде Қазақстан шегіндегі шөлейттену мен жер деградациясының табиғи және антропогенді факторларының өзекті мәселелері, сонымен қатар, бұл үрдістерді ушықтыратын негізгі факторлар қарастырылады. Қазақстандағы топырақ жамылғысының қазіргі жағдайы талданып, шөлейттенген және деградацияланған топырақ картасы құрастырылды.

Үлкен территориялардың шөлейттенуі топырақтың ластануы, тұздануы, жер беті және жерасты суы салдарынан болатын батпақ, эрозия (су, жел) мен өсімдік жамылғысының деградациясынан, жалпы аймақтағы биологиялық өнімділіктің төмендеу салдарынан пайда болады. Топырақ жамылғысының қазіргі жағдайын талдау жұмыстары жер деградациясының қарқындылығын көрсетті. Қазақстан территориясының 43%-ы айтарлықтай дәрежеде деградацияға ұшыраған; 14% жайылым жерлер күрделі деградация дәрежесіне жеткен немесе толық деградацияланған. Қазақстан аумағының 76,3% орташа, айтарлықтай және қатты дәрежеде шөлейттенген. Сонымен қатар, егіс алқаптарындағы дефляция, эрозия және топырақтың тұздануы секілді жағымсыз үдерістердің даму салдарынан құрғақ және дала аймағының көп бөлігі шөлейтті болып келеді.

Арал теңізі ауданын, Солтүстік Каспийдің шөлді жерлері және Оңтүстік Балқаш топырағын қарқынды шөлденген және топырағы тұздану үдерісі мен дефляцияға ұшыраған аудандар ретінде қарастыруға болады.

Кешенді шөлейттену түрі басым әрі республика аумағының 464,0 мың км², яғни 17% алып жатыр. Шөлейттенудің бұл түріне топырақ пен өсімдік жамылғысының деградациясы немесе толық бұзылу техногенді әсер ету жатады.

Түйін сөздер: топырақ деградациясы, шөлейттену, аридті аудан, Қазақстан.

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ОПУСТЫНИВАНИЕ И ДЕГРАДАЦИЯ ЗЕМЕЛЬ В КАЗАХСТАНЕ

Аннотация. Проблема деградации земель является очень актуальной во всем мире, в том числе и в Казахстане. И особое внимание уделяется изучению проблем освоения деградированных земель. Опустынивание и деградация земель является обычным процессом в засушливых и полузасушливых регионах Казахстана, особенно в южных районах, где районы покрыты большими разновидностями типов пустынь. В пустынях почвообразующие процессы протекают в условиях острой нехватки воды и высокого уровня деградации и опустынивания почвы. Основными природными факторами этих процессов являются равнинная местность, высокая степень засушливого климата, засоленность и бесструктурность почв, широкое распространение бурых карбонатных почв и низкое содержание естественного плодородия почв. Однако антропогенные факторы опустынивания и деградации почвы стали доминирующими в последние десятилетия, что сказывается на развитии аграрной отрасли страны.

Процесс деградации приводит к снижению плодородия и продуктивности почв и, соответственно, негативно влияет на состояние почвенного покрова и аграрного сектора в целом. На всех пахотных землях наблюдается потеря гумуса, причем в пределах неорошаемой пашни опустынено за счет дегумификации 11,2 млн.га, орошаемой пашни – 0,7 млн.га., почти треть площади почв орошаемой пашни (31,3%) засолена, что ведет к увеличению солончаковых пустынь. Кроме того, опустынивание также прогрессирует на орошаемых почвах дельт рек Сырдарья, Шу, Или и Каратал.

В Казахстане 165 млн гектаров земель из 280 млн всей территории – это пустынные и полупустынные зоны. Природные полупустынные и пустынные зоны занимают почти 70 % территории Казахстана. В основном это южные и западные регионы, которые наиболее подвержены изменениям почвенного состояния и покрыты песчаными массивами (32 млн.га), солончаками (2,6 млн.га) и плоскими равнинами с такырами (0,3 млн.га).

В исследовании рассматриваются актуальные проблемы природных и антропогенных факторов опустынивания и деградации земель в пределах Казахстана, а также основные факторы, усугубляющие эти процессы, даны анализы современного состояния почвенного покрова в Казахстане, составлена карта опустынивания и деградации почв Казахстана. Опустынивание огромных территорий сопровождается загрязнением почвы, заболачиванием поверхностными и подземными водами, засолением почвы, эрозией (водная, ветровая), деградацией растительного покрова, осушением и снижением общей региональной биологической емкости. Анализ современного состояния почвенного покрова показал интенсивную деградацию земель. 43% территории Казахстана в значительной степени подвержены деградации; более 14% пастбищ достигли критической степени деградации или полностью деградировали, 76,3 % территории Казахстана подвержено опустыниванию умеренной, значительной и сильной степеням. Причем большая часть территории со значительной степенью опустынивания характерна сухостепной и степной зонам за счет развития негативных процессов, таких как дефляция, эрозия и засоление почв в пределах пахотных земель.

Район Аральского моря, пустыни Северного Каспия и Южного Балхаша можно рассматривать как районы интенсивного опустынивания почв, процессов засоления и дефляции почв.

Комплексный тип опустынивания является ведущим и занимает 464,0 тыс.км² (17%) территории республики. Данный тип опустынивания включает техногенное воздействие с деградацией или полным разрушением почвенно-растительного слоя.

Ключевые слова: деградация почв, опустынивание, аридный регион, Казахстан.

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