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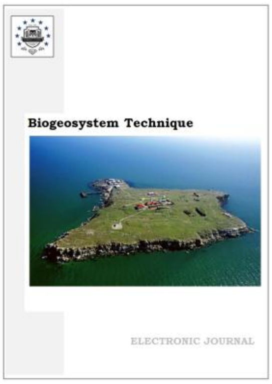

Articles

Soil Erosion in Desert Region and Its Impact on Meliorative Condition

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Abstract

This article presents the research on the deterioration of soil properties under the influence of wind erosion in the "Todakol massivi" in the northern part of Qorovulbazar district of Bukhara region. In particular, the effects of natural stress factors on the growth and development of pasture plants such as white haloxylon (*Haloxylon persicum* L.), black haloxylon (*Haloxylon aphyllum L.*), sagebrush (*Artemisia tenuisecta L.*), tamarisk (*Tamarix hispida L.*), harmel (*Peganum harmala L.*), seta (*Salsola sclerantha L.*), alhagi (*Alhagi sparsifolia L.*), sagebrush (*Salsola arbuscula L.*), black redroot pigweed (*Amaranthus retroflexuss L.*), sedges (*Carex physodes L.*), downy brome (*Bmomus tectorum L.*), barley (*Eremopyrum Orientale L.*), salty crabgrass (*Aeluropus litoralis L.*), alhagi (*Alhagi psudoalhagi L.*), which are widespread in the region, are highlighted. In particular, soil erosion due to the wind in the area and the amount of easily soluble salts in water were determined and analyzed.

Keywords: wind erosion, desertification, soil degradation, soil pollution, soil salinity, flora.

1. Introduction

In recent years, soil pollution, increased salinization and desertification, water and wind erosion have affected the loss of the fertile soil layer. Such processes are clearly felt as a result of the soil spread in the basins of the Zarafshan River and anthropogenic effects on them (Karimov et al., 2021; Namazov, Amonov, 2019; Jabborova et al., 2023). The experience of using remote sensing services of soil and vegetation cover in arid regions has been widely used, including in 2020 and 2021, unfavorable weather and unscientific use of pasture lands caused the rise of dust storms, which resulted in the sand cover of pastures and accelerated the degradation process (Biarslanov et al., 2021, Shinkarenko et al., 2021). Analysis of modern desertification dynamics using geo-information technologies and aerospace data has shown that the area of degraded and desert lands in the region is increasing due to the influence of human factors (Kulik et al., 2020).

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Desertification and degradation of drylands have been studied through years of research to quantify the desertification process (Lazareva et al., 2020).

In recent years, the degradation processes of sandy desert grasslands have become a serious problem in some regions. This process depends on several factors. Quantitative assessment, the effects of the degradation processes of arid windy sandy areas on soil properties and their changes have been studied (Ma et al., 2022; Abdullaev, Nomozov, 2024). Effects on desert soils resulted in reductions in soil microbial biomass, enzyme activity, and nematodes (Yang et al., 2018; Jabbarov et al., 2024). Dunes were formed as a result of wind erosion in desert regions where vegetation is sparse (Zang et al., 2018).

In recent years, as a result of sudden changes in climate, the level of soil and vegetation degradation in the sandy desert areas has reached 35.7 %, and it has been determined that the current state of grassland ecosystems in the Kyzylkum desert will undergo serious changes (Yusupov et al., 2010). The condition of grassland ecosystems in the sandy desert massiv was comprehensively evaluated, and according to the research results, the development of degradation processes and the loss of natural fertility were observed as a result of irregular use of pastures (Bayrakov, 2012; Jabbarov et al., 2024). In the desert zone, pastures, which are being excessively lost due to long-term monitoring of their land, occupy a small part of the Caspian lowland (Mashtikov, 2018, 2021). Biodiversity has been significantly damaged by changes in soil properties in the desert region by disrupting the water requirements of plants (Tashninova, 2018; Djapova et al., 2019). The process of desertification is active in various regions and is considered a major problem in changing the soil and vegetation cover (Badmaeva et al., 2019).

FAO and UNESCO organizations have studied the desert region into several groups and named them as gray-brown, barren, sandy desert soils (Pankova, Gerasimova, 2012). In the Bukhara oasis, scientists conducted extensive research on the formation of desert soils, the hydrogeological regime of their origin, climate, and soils (Shadieva et al., 2021). In order to study the degradation of sandy desert soils, their distribution, mechanical composition, humus content, presence of total and mobile nutrients in the soil, salinity level were studied (Sattorova, Turaeva, 2022; Abdrahmanov et al., 2024).

Based on research conducted in desert areas, it is scientifically proven that various ecological problems and changes in vegetation cover are caused by relief features, soil-forming rocks, and moisture conditions (Shulgina et al., 2018; Kalibekova, Kojabergenova, 2021; Abdrahmanov et al., 2024).

It has been scientifically proven that the soils of the desert zone located in different regions of Kazakhstan differ in terms of regional climate characteristics, morphogenetic and chemical properties of soils, organic substances in their composition, and their group composition (Razakov et al., 2019; Jarnikova, Alimbaeva, 2018). The formation processes of sandy desert soils, the formation of soils, their specific water regime and capillarity create a specific water regime (Kholdorov et al., 2023; Valeysha, 2020). It has been found that plants in desert soils are severely damaged by wind erosion (Turdaliyev et al., 2022). In the desert region, the reduction of vegetation as a result of degradation leads to the activation of soil salinization (Neronov, 2018; Jabbarov et al., 2023).

2. Study area

The research was carried out in the "Todakol massiv" in the northern part of Qorovulbazar district of Bukhara region. This area is mainly degraded and used as pasture, hilly semi-fortified sandy desert and alluvial-proluvial and lacustrine deposits (Figure 1).

Qorovulbazar district of Bukhara region was established on January 12, 1993. This district borders with Bukhara district in the north, Mubarak district of Kashkadarya region in the south, Olot district in the west, and Kyzyltepa district of Navoi region in the east. The relief consists of low and high hills, divided by old riverbeds. The total area of the district is 219,580 hectares.

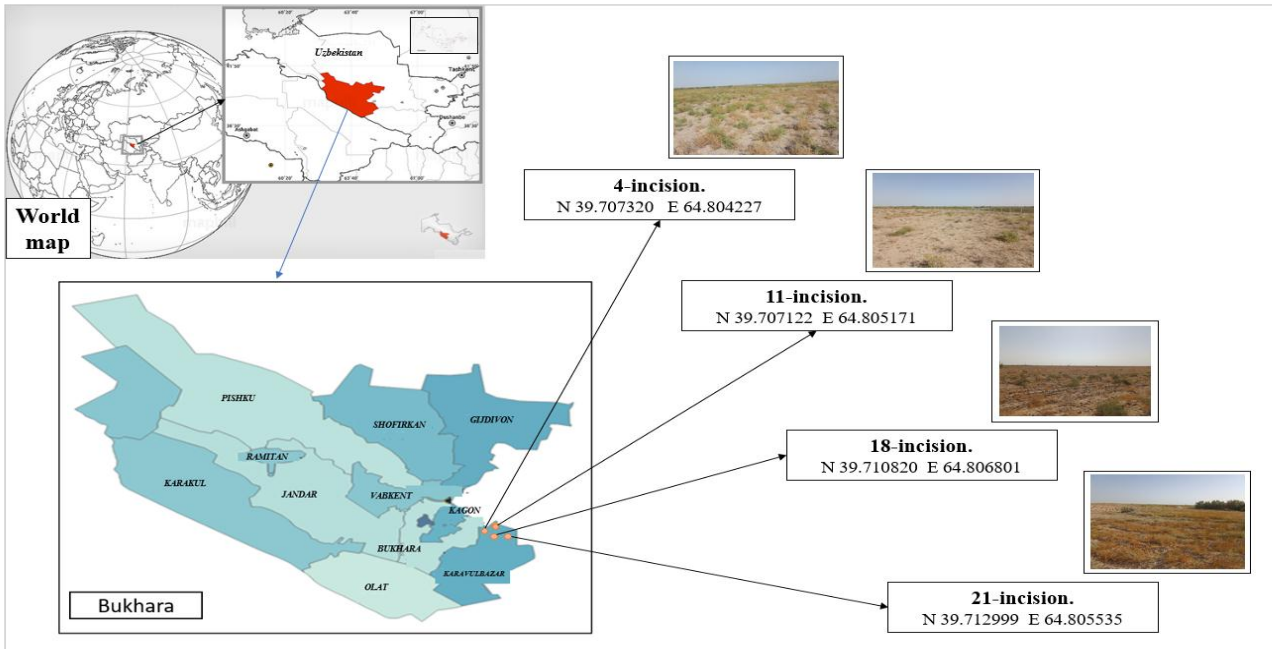

Fig. 1. Geographic location coordinates of the research area , 2024

3. Materials and methods

3.1. Flora distributed in the study area

The geographical distribution of plants in the research area is divided into two groups: that is, plants distributed in sandy desert and irrigated areas. Grasslands are the main part of the plants scattered in the sandy deserts of the oasis. These plants also protect the soil from wind erosion. Their vegetation period is short, 210-215 days plants such as white haloxylon (Haloxylon persicum L.), black haloxylon (Haloxylon aphyllum L.), sagebrush (Artemisia tenuisecta L.), tamarisk (Tamarix hispida L.), harmel (Peganum harmala L.), seta (Salsola sclerantha L.), alhagi (Alhagi sparsifolia L.), sagebrush (Salsola arbuscula L.), black redroot pigweed (Amaranthus retroflexuss L.), sedges (Carex physodes L.), downy brome (Bmomus tectorum L.), barley (Eremopyrum Orientale L.), salty crabgrass (Aeluropus litoralis L.), alhagi (Alhagi psudoalhagi L.) are common (Figure 2).

Fig. 2. Plant species distributed in the study area
Note: *(A)- alhagi Alhagi sparsifolia L., (B)-harmel Peganum harmala L.,*
(C) – black haloxylon Haloxylon aphyllum L., (D)-tamarisk Tamarix hispida L.

Currently, 528 unique species of plants can be found in the Bukhara oasis. These plants are common in oasis desert, sandy desert and irrigated areas. 220 types of weeds were found among agricultural crops in irrigated fields. Among them, there are 89 species with a wide geographic distribution specific to this ecological environment (Gafurova et al., 2020).

3.2. Soils distributed in the study area

Different soil covers are found in the territory of Bukhara oasis, which is directly related to the low location of the area, the complex structure of the earth's surface, the variety of soil-forming rocks, climatic conditions, the character of the flora and human activities. Subsoils are not compacted, have good water permeability, and have varying degrees of salinity. The main part of the territory is occupied by the desert region. The soils are sandy desert grassland and grassy desert soils, and their deep layers are mainly covered with humus deposits containing quaternary sediments (Artikova, 2019). Sandy desert soils are different from other types of soils, they are automorphic soils, groundwater is very deep, they are distributed in the deltas of subaerial rivers in the Karakum and Kyzylkum regions of Central Asia, and ancient alluvial and marine deposits are considered the parent rock. Such soils are distributed in Fergana, Kyzylkum, Karshi, Sherabad, Bukhara, Khorezm and Aral regions. The parent rock is of great importance in the process of soil formation. This process has a number of unique important features, as a result of this process, new substances are formed depending on the composition of the initial parent rock that forms the soil. According to the morphological structure of the soil of the study area, it is sandy desert soil, consolidated sand, sandy land with sparse vegetation covers very large areas. They belong to weakly saline soils, and due to the complexity of the terrain and the composition of scattered sands, they cause difficulties for development (Table 1).

Table 1. Morphological classification of soil layers of the study area

Soil cross section number	Section depth	Morphological classification
Cross section 4	0-28	Light gray, dry, sandy, with a soft, fine powdery structure, small roots are found in small quantities, there are no salt spots, the transition is according to the clear structure.
	28-48	Light gray, dry, weakly compacted, sand, small amount of fibrous rootstocks, low moisture, few salt points, transition gradually according to the structure.
	48-71	It consists of light clay sometimes gray, dry, sandy, loose sand, moderately compacted, small amount of salt spots, moisture is present, small calcareous stones are very rare, hairy rhizomes of flowing color are found, the transition is gradual.
	71-93	Light yellowish gray, sandy, moderately compacted, loose sand, hairy rootlets occur, moisture present, carbonates punctate and veined, transition gradual.
	93-131	The flow is gray, dry, sandy, moderately compacted, floury gypsum fragments and small CO2 concretions are present, moisture is present, calcareous stones are present but very few, transition is noticeable.
Cross section 11	0-25	Light gray, sometimes runny, dry, sand has a soft powdery structure, granular rhizomes are found in small quantities, there are no salts, the transition is clear in structure.
	25-52	Light gray, dry, weakly compacted, sandy, with a small amount of filamentous rhizomes, consisting of loose sand, with a small amount of moisture, with a small amount of salt spots, the transition is gradual in structure
	52-83	Consisting of light gray sometimes gray, dry, scattered sand, moderately compacted, few salt spots, moisture present, small pebbles few, oozing hairy rhizomes few, sparse salt spots, gradual transition in texture
	83-115	Light yellowish-gray sand, moderately compacted, with hairy roots, loose sand, carbonates punctate and veined, moisture present, transition slow.
	115-140	The flow is gray, dry, sandy, moderately compacted, floury gypsum fragments and small CO2 concretions are present, moisture is present, calcareous stones are present but very few, transition is noticeable.
Cross section 18	0-15	Light gray, sometimes tinged, dry, the sand is soft powdery, granular roots are found, there are no salts, the transition is according to the clear structure.

Soil cross section number	Section depth	Morphological classification
	15-32	Light gray, dry, weakly compacted, sand, small amount of fibrous roots, small amount of dusty salt spots, gradual transition in structure.
	32-55	It consists of light clay-colored sometimes gray, dry, sandy, moderately compacted, loose sand, small amount of salt spots, small amount of moisture, small calcareous stones, small amount of hairy rootlets, transition is gradual.
	55-83	Light yellowish-gray, sandy, moderately compacted, scattered sands, hairy rootlets are found, moisture is present, carbonates are punctate and veined, transition is gradual.
	83-125	The flow is grey, dry, sandy, moderately compacted, flocculent gypsum flakes and small CO_2 concretions are present, moisture is present, calcareous stones are present but very few, transition is noticeable.
Cross section 21	0-18	Light gray, sometimes tinged, dry, sand is soft powdery, granular roots are found, salts are not present, the transition is by clear structure.
	18-38	Light gray, dry, weakly compacted, sand, small amount of fibrous roots, small amount of dusty salt spots, gradual transition in structure.
	38-47	It consists of light clay-colored sometimes gray, dry, sandy, moderately compacted, loose sand, small amount of salt spots, small amount of moisture, small calcareous stones, small amount of hairy rootlets, transition is gradual.
	47-78	Light yellowish-gray, sandy, moderately compacted, scattered sands, hairy rootlets are found, moisture is present, carbonates are punctate and veined, transition is gradual.
	78-108	The flow is grey, dry, sandy, moderately compacted, flocculent gypsum flakes and small CO_2 concretions are present, moisture is present, calcareous stones are present but very few, transition is noticeable.

Sandy desert soils distributed in the desert region have their own morphological and genetic characteristics. Sandy desert soils are formed on sand, according to the origin of sand, it is divided into alluvial and parent rock sand. Alluvial sands were formed from the modern deposits of the Zarafshan River. One of the characteristics of irrigated sandy desert soils is the weak expression of genetic layers on the outside. One of the unique features of these soils is the low amount of carbonate and the absence of silt formation in the upper layer. All processes taking place in the soil are related to their mechanical composition. According to the mechanical composition of the soil, the research area is light, medium and heavy sand, and some places are sandy loam (Gafurova et al., 2020).

3.3. Laboratory analysis methods

In the study of the properties of degraded sandy desert soils distributed in the Todakul massiv of the Qorovulbazar district of Bukhara region, the generally accepted profile in soil science was studied on the basis of methods such as genetic, morphological, comparative geographical, and on the basis of methods generally accepted in laboratory conditions. V. Sayfutdinova's study guide was used to take soil samples and determine the amount of water-soluble cations and anions in the soil (Sayfutdinova, 1992).

The following work was carried out under field conditions:

– Studies were carried out on the study of the natural geographical location, soil cover, distribution of vegetation, and ecological conditions of the research area;

– Studies of climate conditions and drought level of the research area were carried out;

– Work was carried out to study the effect of wind erosion on the soils of the research area;

– Soil samples were taken from the research area;

– In order to improve the degraded soils of the research area, artificial planting of desert pasture plants was carried out;

– To improve the degraded soils of the research area, field experiments were conducted using eco-gumin organic fertilizer and hydrogel polymer substance on desert pasture plants;
– The number of naturally distributed pasture plants in the research area was calculated using the 4x100 transect method.

Soil analyzes were carried out in the following ways:
– Determination of soil salinity types according to Yu.P. Lebedev's classification;
– Determination of soil salinity according to O.K.Komilov, A.U.Akhmedov classification;
– Chlorine ion according to Mor's method;
– Dry residue based on evaporation of the solution and weighing of the precipitate;
– Correlation coefficient was performed in Microsoft Excel program and statistical analysis of obtained results was performed in Excel STAT interface.

4. Results and discussion

4.1. Indicators of soil deflation in the study area under the influence of wind

Today, desertification and land cover degradation caused by climate change is one of the major problems around the world. The desertification causes the formation and evolution of sandy soils, especially in areas with limited water resources. This is typical in many areas of the Bukhara region. In the Bukhara region, the soil fertile upper part is blown away in a deflation process under the influence of the wind. According to the information of the Hydrometeorological Service Center of the Republic of Uzbekistan, it was observed that during the period of 2012-2022, due to the influence of wind erosion, soil particles with a size of 0.25 mm were regularly eroded by wind (Table 2).

Table 2. Variation of wind speed and erosion rates of sandy desert soils in the study area (Hydrometeorological Service Center of the Republic of Uzbekistan, 2023)

No	Year	Maximum wind speed, m/s	Erodible soil particles, mm	Average wind speed, m/s	Erodible soil particles, mm
1	2012	15.8	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.3	0.25
2	2013	16.6	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.3	0.25
3	2014	15.6	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.2	0.25
4	2015	16.0	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.3	0.25
5	2016	17.0	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.1	0.25
6	2017	17.3	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.3	0.25
7	2018	16.9	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.5	0.25
8	2019	15.4	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.4	0.25
9	2020	16.8	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.2	0.25
10	2021	17.2	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.4	0.25
11	2022	16.6	0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3	3.3	0.25

According to the results of the analysis, the maximum wind speed of the soils in the study area varied by 0.3-2.3 m/s between 2012 and 2022. The wind speed index increased, which led to an increase in the wind erosion. Therefore, in the last 11 years in the study area, it was found that

0.25; 0.25-0.5; 0.5-1.0; 1-2; 2-3 mm particles in the soil were eroded, 0.25 mm particles in the soil were eroded at the average speed of the wind.

4.2. The amount of easily soluble salts in the soils of the study area

Various salts in the soil have a negative effect on the growth and development of plants. As a result of an increase in the amount of salt in the soil, an increase in soda, chloride and sulfates in it, the quality of the soil deteriorates, its productivity decreases and the degradation processes increase. In this regard, in order to determine the soil mineralization in the scientific research area, the samples taken from the soil sections were analyzed in laboratory conditions using the methods that passed the state standards (Table 3).

Table 3. The amount of easily soluble salts in the soil of the study area

Layer thickness, cm	Dry residue, %	HCO_3	Cl-	SO_4^{--}	Ca^{++}	Mg^{++}	Na+	Salinity	
								Type	Degree
Section 1									
0-28	0.118±0.2	0.037±0.02	0.016±0.03	0.022±0.02	0.003±0.002	0.002±0.001	0.018±0.02	ch.s	weakly saline
28-48	0.116±0.3	0.035±0.03	0.015±0.02	0.018±0.01	0.008±0.001	0.002±0.002	0.017±0.03	ch.s	
48-71	0.115±0.2	0.034±0.04	0.016±0.01	0.020±0.03	0.009±0.001	0.004±0.001	0.012±0.02	ch.s	
71-93	0.176±0.4	0.030±0.03	0.018±0.02	0.026±0.02	0.056±0.002	0.005±0.001	0.021±0.03	ch.s	
93-131	0.131±0.2	0.035±0.02	0.022±0.03	0.026±0.04	0.002±0.001	0.004±0.02	0.023±0.04	ch.s	
Section 11									
0-25	0.125±0.3	0.035±0.02	0.015±0.04	0.024±0.02	0.008±0.001	0.002±0.001	0.020±0.02	ch.s	weakly saline
25-52	0.115±0.2	0.036±0.03	0.017±0.02	0.019±0.03	0.009±0.002	0.004±0.002	0.011±0.01	ch.s	
52-83	0.122±0.4	0.034±0.02	0.018±0.03	0.021±0.01	0.011±0.01	0.004±0.001	0.014±0.02	ch.s	
83-115	0.150±0.3	0.034±0.03	0.021±0.02	0.026±0.02	0.025±0.02	0.004±0.002	0.021±0.03	ch.s	
115-140	0.169±0.2	0.032±0.02	0.018±0.04	0.026±0.03	0.046±0.03	0.005±0.002	0.022±0.02	ch.s	
Section 18									
0-15	0.127±0.2	0.037±0.04	0.018±0.02	0.024±0.03	0.008±0.002	0.002±0.001	0.018±0.02	ch.s	weakly saline
15-32	0.128±0.3	0.037±0.02	0.024±0.03	0.018±0.02	0.011±0.02	0.003±0.001	0.016±0.03	s.ch	
32-55	0.118±0.2	0.035±0.03	0.015±0.02	0.020±0.03	0.009±0.002	0.004±0.002	0.015±0.02	ch.s	
55-83	0.152±0.3	0.034±0.02	0.023±0.03	0.026±0.01	0.021±0.02	0.005±0.003	0.023±0.03	ch.s	

Layer thickness, cm	Dry residue, %	HCO_3	Cl-	SO_4^{--}	Ca^{++}	Mg^{++}	Na+	Salinity	
								Type	Degree
83-125	0.190± 0.4	0.030± 0.03	0.018± 0.01	0.024± 0.02	0.071± 0.03	0.005± 0.002	0.022± 0.01	ch.s	
Section 21									
0-18	0.139± 0.2	0.034± 0.02	0.016± 0.02	0.036± 0.02	0.012± 0.02	0.002± 0.001	0.019± 0.02	ch.s	weakly saline
18-38	0.117± 0.4	0.037± 0.03	0.019± 0.01	0.018± 0.03	0.008± 0.001	0.002± 0.001	0.013± 0.01	s.ch	
38-47	0.133± 0.3	0.035± 0.02	0.025± 0.02	0.020± 0.01	0.009± 0.002	0.004± 0.002	0.019± 0.02	s.ch	
47-78	0.174± 0.2	0.030± 0.04	0.018± 0.03	0.026± 0.02	0.053± 0.03	0.005± 0.003	0.022± 0.03	ch.s	
78-108	0.188± 0.3	0.030± 0.02	0.018± 0.02	0.026± 0.03	0.066± 0.02	0.005± 0.002	0.023± 0.02	ch.s	

Notes: (ch.s) – Chloride sulfate, (s.ch) Sulphate chloride. The results of the laboratory analysis were carried out in 3 repetitions and the average values were obtained

In the northern part of the Qorovulbazar district of Bukhara region, the total soil dry residue content fluctuated between 0.115±0.2 % and 0.190±0.4 % according to the amount of easily soluble salts in the soil layers. The 21st soil cross section with the highest amount of dry residue was considered. The amount of HCO3 in terms of total alkalinity was from 0.030±0.04 % to 0.037±0.03 %. Among the anions distributed in this cross section, a Cl- ion content was from 0.016±0.02 % to 0.025±0.02 %, a SO4-- ion content was from 0.018±0.03 % to 0.036±0.02 %. According to the amount of cations, it was determined that a Ca++ ion content fluctuated from 0.008±0.001 % to 0.066±0.02 %, a Mg++ ion content ranged from 0.002±0.001 % to 0.005±0.003 %, and a Na+ ion content was from 0.019±0.02 % to 0.023±0.02 %. The soil salinity degree was determined to be weakly saline and chloride-sulfate (ch.s) and sulfate-chloride (s.ch) types according to the type of salinity.

The amount of dry residue was determined at least in the 4th cross section. The amount of dry residue fluctuated between 0.115±0.2 % and 0.131±0.2 % in the layers. According to the total alkalinity, the amount of HCO3 was from 0.030±0.03 % to 0.037±0.02 %. Among the anions distributed in this section, a Cl^- ion content was from 0.015±0.02% to 0.022±0.03%, a SO4-- ion content was from 0.018±0.01 % to 0.026±0.02 %. According to the amount of cations, it was determined that a Ca++ ion content oscillated from 0.002±0.001 % to 0.056±0.002 %, a Mg^{++} ion content was from 0.002±0.001 % to 0.005±0.001 %, and a Na+ ion content was from 0.012±0.02 % to 0.023±0.04 %. The salinity degree is weakly saline, and according to the type of salinity, it was determined that all layers are of chloride-sulfate (ch.s) type.

5. Conclusion and recommendations

The analysis of the data over the years shows that the soil layers in the northern part of Qorovulbazar district of Bukhara region are exposed to increase in wind speed and as a result the erosion of soil particles is one of the main factors that reduce soil fertility. In overcoming the soil erosion, the force of the wind can be reduced by planting trees and shrubs. These measures can be effective in maintaining soil fertility and preventing wind erosion.

According to the degree of salinity, it was determined that the soils are weakly saline, and the type of salinity belongs to chloride sulfate (ch.s) and sulfate chloride (s.ch) types. These results indicate that the soils in the area are in the early stages of the salinization process, and the composition and amount of salts may have a negative impact on soil fertility. Therefore, it is necessary to take these factors into account when carrying out agricultural activities on the soils of the area. Special agrotechnical measures are required to take additional reclamation measures and increase soil fertility.

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