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Salt resistance of species of the Chenopodiaceae family (Amaranthaceae s.l.) in the desert part of the Syrdarya River Valley, Kazakhstan

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Abstract. *Osmonali BB, Vesselova PV, Kudabayeva GM, Duisenbayev S, Taukebayev O, Zulpykharov K, Ussen S, Abdildanov DSH. 2024. Salt resistance of species of the Chenopodiaceae family (Amaranthaceae s.l.) in the desert part of the Syrdarya River Valley, Kazakhstan. Biodiversitas 25: 4162-4170.* Salt tolerance is a complex ecological strategy: halophytes have adaptive physiological and anatomical modifications to 'combat' the damaging effects of osmotic and metabolic stress that cause impaired growth and reproduction. Halophytes are represented in many angiosperm families that are distributed worldwide. Halophytes represent a heterogeneous group of plants that combine representatives of different taxa, life forms, ecological types, and floras. The family Chenopodiaceae belongs to the largest and oldest families in arid territories of the globe. It occupies the leading position in the spectrum of families of the desert floras of Kazakhstan. The choice of the study region—the desert part of the Syrdarya River Valley within Kyzylorda oblast, Republic of Kazakhstan—is conditioned by a wide distribution of saline territories within its limits, to which the overwhelming majority of species of the studied family are confined. The objects of the study are phytocenoses (communities) located in saline and non-saline areas with the participation or dominance of Chenopodiaceae (Amaranthaceae s.l.) species in the desert part of the Syrdarya River Valley. Distribution of studied taxa on preference to one or another degree of salinity at genus level showed certain peculiarities. In particular, it was revealed that species of genera *Atriplex*, *Caroxylon*, and *Bassia* grow, as a rule, on soils from non-saline to slightly saline. In turn, species of the *Suaeda* genus prefer to settle on soils of medium and high saline. Finally, the species categorized as hyperhalophytes (preferring a high degree of salinity) belong exclusively to one subfamily, Salicornioideae. This indicates a certain direction of evolution of the adaptive characteristics of representatives of this family.

Keywords: Arid region, communities, desalinization, dominants, edificators, halophytes, salinized soil

Abbreviations: ClS: Chloride-Sulphate; ClSu+S: Chloride-Sulphate with participation of Soda; CM: Calcium-Magnesium; CS: Calcium-Sodium; GOST: State Standard; IPNI: International Plant Names Index; MC: Magnesium-Calcium; MS: Magnesium-Sodium; S: Sodium; SC: Sodium-Calcium; SM: Sodium-Magnesium; Su: Sulphate; Su+S: Sulphate with participation of Soda

INTRODUCTION

Among angiosperms, only 1%-2% of species belong to halophytes (Flowers and Colmer 2015). Salt tolerance is a complex ecological strategy; halophytes have adaptive physiological and anatomical modifications to 'combat' the damaging effects of osmotic and metabolic stress, causing impaired growth and reproduction (Flowers and Colmer 2015). Halophytes are represented in many angiosperm families, with species distributed worldwide (Wang et al. 2015). It should be noted that salt tolerance in angiosperms has evolved repeatedly (Flowers et al. 2014; Benjamin et al. 2018). The patterns of evolutionary processes of salt tolerance in plants have been studied in detail in only a few taxonomic groups. As a result, two quite different patterns (Chenopodiaceae and Poaceae) of salt tolerance evolution have been identified. In the group Chenopodiaceae, salt tolerance appears to be phylogenetically conservative (Kadereit and Freitag 2011; Kadereit et al. 2012, 2017; Mansour and Ali 2017; Vandelook et al. 2021), occurring only once or twice in the history of the group and then persisting in a large proportion of species in the family. Some halophytes exhibit complex anatomical modifications, such as salt glands or hairs, among others. However, most halophytes 'apply' osmotic regulation by modifying existing physiological mechanisms to reduce salinity within the plant (Moray et al. 2015). These strategies can also vary among closely related halophytes and halophytes occupying similar habitats (Kadereit et al. 2012; Moray et al. 2015; Ankova et al. 2020; Almerekova et al. 2024).

Excessive salt content in soil is one of the main factors limiting plant growth and productivity (Flowers and Colmer 2015; Rozentsvet et al. 2018, 2021a, 2021b, 2022). Saline soils are variously estimated to comprise between 15% and 23% of the total land area of the Earth’s landmass The increase in saline areas due to global climate change, the spread of irrigation, and population growth threaten human health, ecosystems, and national economies (Flowers et al. 2014; Rakhmankulova et al. 2015; Rozentsvet et al. 2018, 2022; Morales-Briones et al. 2020).

The qualitative composition of salts contained in the soil determines the positive or negative effects they have on plant growth. For example, Na+ is known to be the main toxic ion in most plants. The presence of the most abundant anion, Cl-, in the soil is also sensitive for many plants. Thus, high concentrations of Na+ and/or Cl+ in soil cause so-called osmotic stress in plants, associated with a sharp drop in the water potential of the rooting medium. In the case of their excessive intake into cells, a shift in ionic balance occurs, disrupting the natural course of many physiological and biochemical processes (Rakhmankulova et al. 2015; Rozentsvet et al. 2022).

Halophytes represent a heterogeneous group of plants, combining representatives of different taxa, life forms, ecological types, and floras (Yuan et al. 2019; Ivanov et al. 2020). Salt tolerance of halophytes is provided, as a rule, by the simultaneous action of several mechanisms at once, and only rarely by one of them (Rozentsvet et al. 2014). However, the entire range of adaptive mechanisms is not realized in different halophytes to the same extent. Soil salinization is one of the types of land degradation that leads to desertification over time (Shuyskaya et al. 2019). The accumulation of salts in soil horizons alters the growing environment of plants, eventually leading to the deterioration of ecological conditions (Nan and Guo 2021).

The family Chenopodiaceae belongs to the largest and oldest families in arid territories of the globe. It occupies a leading position in the spectrum of families of the desert floras of Kazakhstan. A number of representatives of the family, being dominants and edifiers of many desert communities, play an important role in the composition of vegetation cover (Osmonali et al. 2021). It should be noted that, although there are numerous works related to the salt tolerance of plants, it is extremely rare to find works as an editor and on the complex of species with indices of soil salinity types (Rufo et al. 2021; Song et al. 2022; Sukhorukov et al. 2022; Vesselova et al. 2022).

The choice of the study region—the desert part of the Syrdarya River Valley within Kyzylorda oblast, Republic of Kazakhstan—is conditioned by the wide distribution of saline areas within its boundaries, to which the overwhelming majority of species of the studied family are confined. They are widely represented in various desert ecotopes, including clay and sandy deserts, where they form various phytocenoses, associations, and formations.

MATERIALS AND METHODS

The objects of the study are phytocenoses (communities) located in saline and non-saline areas with the participation or dominance of species of Chenopodiaceae (Amaranthaceae s.l.) in the desert part of the Syrdarya River Valley (Kyzylorda oblast, Kazakhstan). Using the QGIS program, a map of the points of the studied specimens was made (Figure 1).

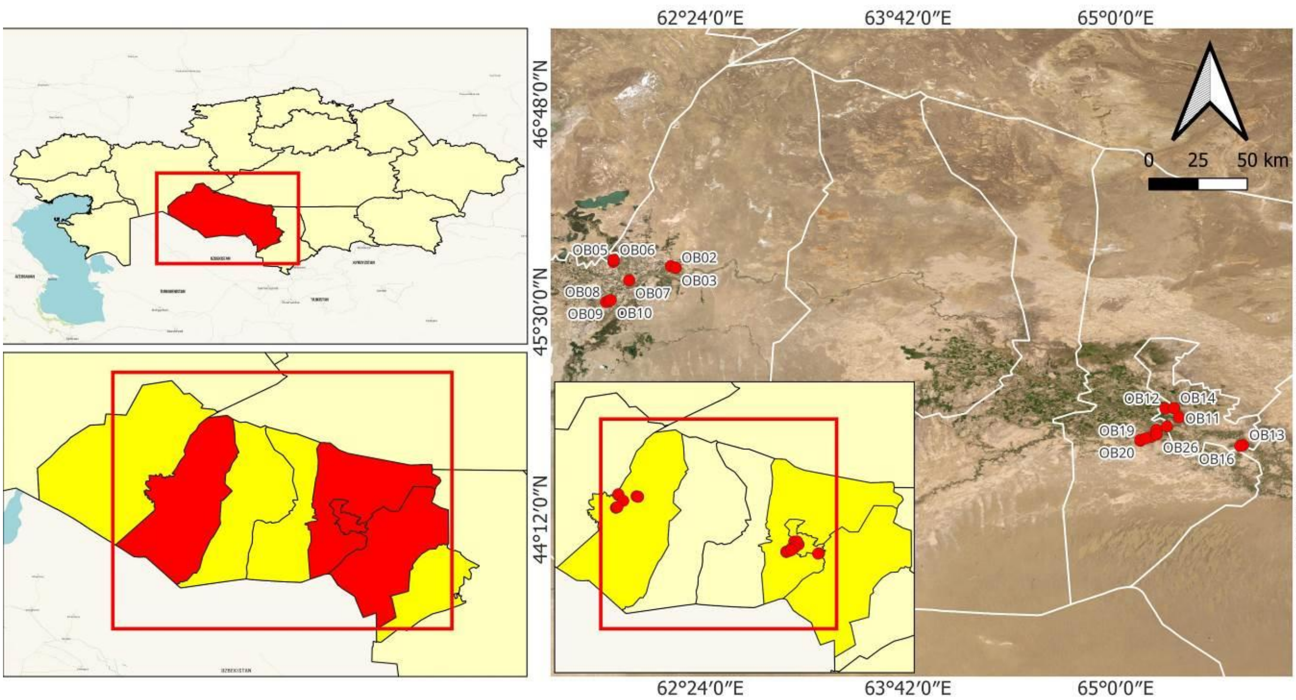

Figure 1. Map showing the points of the described communities and selected soil samples, the points are indicated as OB01-0B26. Since some communities were quite close to each other, they overlapped

Table 1. Data from the described points, indicating the name of the communities and the type of soil

Number of the soil section	Coordinates (N, E)	Community	Soil
OB01	45.785567 N 62.215433 E	Alfalfa field (agrocenosis)	loam
OB02	45.776167 N 62.245217 E	Caspici Halostachetum - australi Phragmitosum	loam
OB03	45.77595 N 62.2452 E	Strobilaci Halocnemetum	loam
OB04	45.812217 N 61.855983 E	Caspici Halostachetum - australi Phragmitosum	loam
OB05	45.8236 N 61.856517 E	Climacoptetum	clay
OB06	45.8242 N 61.857517 E	Caspici Halostachetum	loam
OB07	45.696867 N 61.954783 E	Angustifoli Elaeagnetum	clay
OB08	45.561283 N 61.8101 E	Climacoptetum - australi Phragmitosum	loam
OB09	45.567883 N 61.8273 E	Australi Phragmitetum	clay
OB10	45.573383 N 61.839567 E	Australi Phragmitetum	clay
OB11	44.839883 N 65.39735 E	Populetum	loam
OB12	44.895283 N 65.311567 E	Populetum	loam
OB13	44.666317 N 65.798567 E	Populetum	loam
OB14	44.8981 N 65.366133 E	Populetum	loam
OB15	44.896883 N 65.365617 E	Populetum	sand
OB16	44.65995 N 65.779627 E	Aphylli Haloxyletum	sandy loam
OB17	44.740133 N 65.254367 E	Microphylli Suaedetum - aphylli Haloxylosum	loam
OB18	44.754233 N 65.255233 E	Halodendroni Halimodendretum - littorali Aeluroposum	loam
OB19	44.692667 N 65.15495 E	Shrubby	sand
OB20	44.698383 N 65.15425 E	Populetum	sandy loam
OB21	44.717567 N 65.224433 E	Climacoptetum	sandy loam
OB22	44.70775 N 65.187267 E	Caspici Halostachetum	loam
OB23	44.760867 N 65.257617 E	Weeds	loam
OB24	44.76085 N 65.256017 E	Shrubby	sandy loam
OB25	44.782183 N 65.321367 E	Populetum	loam
OB26	44.731733 N 65.257567 E	Halodendroni Halimodendretum	loam

During the expedition period (2020-2023), 26 soil transects were made in the study area with a detailed description of the phytocenoses associated with them with the dominance (or participation) of representatives of marestail. From 26 soil transects, 91 soil samples were collected (two to five samples from each transect, depending on the nature of the transect). In most cases, there were three or four samples from each soil transect (Table 1). Illustrations of the species under study are partially presented in Figure 2.

Classical methods of geobotanical description were used. A description site was randomly selected, and a 15 × 15 meter square was placed at the survey point. The community was described according to the Drude scale, and the dominant species and approximate projective cover were identified (Orazov et al. 2022; Osmonali et al. 2022, 2023a; Kusmangazinov et al. 2023; Sumbembayev et al. 2023; Kubentayev et al. 2024). The most representative place for soil analysis was also selected in this plot. The transect for soil sampling was carried out in the following order. First came the selection of the site and directional identification; a hole was then dug in the size of 80 cm by 100-120 cm, and soil was thrown on the sides. The depth of the cut reached 100 cm; the soil cut was described first by horizons. From each soil horizon, a soil sample was taken, in order, from bottom to top (Vesselova et al. 2022; Kulymbet et al. 2023).

When selecting communities for the study, the need to cover a variety of soil types to which they are confined was taken into account. In the process of describing soil transects, the task was set to study such soil features as their mechanical (sand, sandy loam, clay, loam) composition and degree of salinity (non-saline, slightly, moderately, strongly, or very strongly saline). As a result of chemical analysis of selected soil samples, the following were determined: humus content, aqueous pH, content of easily soluble salts, and composition of aqueous extract.

For identification of species of the family Chenopodiaceae, we used fundamental compilations: “Flora of Kazakhstan,” “Illustrated Identifier of Plants of Kazakhstan,” and “Identifier of Plants of Central Asia,” as well as modern literature data on the studied region (Osmonali et al. 2021, 2022, 2023b; Vesselova et al. 2022). The names of the plant species were given according to the International Plant Names Index (IPNI) database.

Collection of material for soil analyses was carried out during expeditionary studies in the Syrdarya River Valley (2020-2023). The following instructional and methodological documents were used: Instruction on conducting large-scale soil surveys of lands of the Republic of Kazakhstan and systematic list and main diagnostic indicators of soils of the plain territory of the Republic of Kazakhstan.

A general route survey of the area to be studied was carried out to identify the distribution patterns of soils and soil-forming rocks and their relationship with vegetation. Route surveys of the territory included clarification of landscape, geomorphological, and hydrogeological conditions, determining their impact on soils (Ma et al. 2019; Duan et al. 2022; Mukhamediev et al. 2023).

A reconnaissance survey allowed us to visually establish the initial condition of soils, the nature of their use, and potentially possible degradation factors to outline the locations of soil transects.

The transects were laid out in the field period, taking into account the character of relief (meso and microrelief) and vegetation, type, and degree of degradation (disturbance). Special attention was paid to the most common types of degradation in the study area: secondary salinization, erosion, pasture digression, and over-consolidation of soils (Laiskhanov et al. 2023).

The morphological properties of the soil profile were described in the preceding section, and soil samples were taken for chemical analysis. The field genetic name of soil was determined based on morphological description.

Soil sampling was performed in accordance with the requirements of GOST 17.4.3.01-2017, Nature Protection Soils: General requirements for sampling GOST 17.4.4.02-2017 soils; Methods of sampling and preparation of samples for chemical analysis (Zhang et al. 2020; Duan et al. 2022).

Chemical analyses were carried out in the Laboratory of Chemical Analyses of Kazakh Research Institute of Soil Science and Agrochemistry, named after the U. U. Uspanov LLP in Almaty. The U. U. Uspanov Kazakh Research Institute of Soil Science and Agrochemistry LLP in Almaty city has licenses to carry out these types of analyses.

For interpretation and visual convenience, all obtained results of chemical analyses were processed using OriginPro 2024 software (OriginLab, Northampton, Massachusetts, USA).

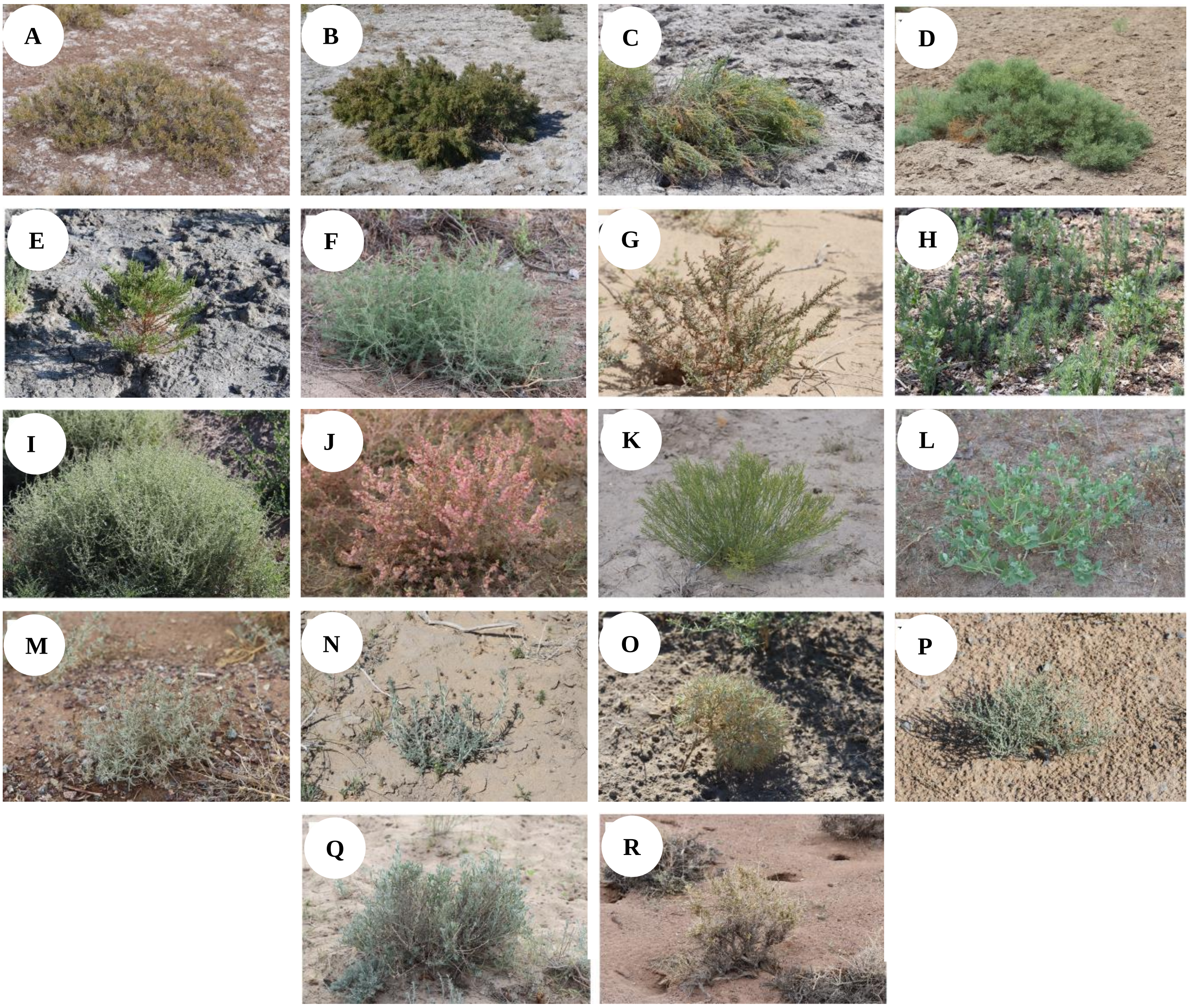

Figure 2. Illustrations of the species being studied. A: *Halocnemum strobilaceum* (Pall.) M.Bieb.; B: *Halostachys capsica* (M.Bieb.) C.A.Mey.; C: *Kalidium foliatum* (Pall.) Moq.; D: *Kalidium capsicum* (L.) Ung.-Sternb.; E: *Salicornia europaea* (Moss) Lambinon & Vanderp.; F: *Suaeda microphylla* (C.A.Mey.) Pall.; G: *Suaeda acuminata* (C.A.Mey.) Moq.; H: *Suaeda linifolia* Pall.; I: *Salsola tragus* L.; J: *Climacoptera lanata* (Pall.) Botsch.; K: *Anabasis aphylla* L.; L: *Atriplex dimorphostegia* Kar. & Kir.; M: *Pyankovia brachiate* (Pall.) Akhani & Roalson; N: *Bassia prostrata* (L.) Beck; O: *Ceratocarpus utriculosus* Bluket ex Krylov; P: *Caroxylon nitrarium* (Pall.) Akhani & Roalson; Q: *Krascheninnikovia ewersmanniana* (Stschegl. ex Losinsk.) Grubov; R: *Xylosalsola arbuscula* (Pall.) Tzvelev

RESULTS AND DISCUSSION

According to the analysis of humus availability in the soil, the data were obtained, according to which the highest and lowest amounts of organic matter at certain points were identified. At sampling points OB07, OB10, OB11, OB14, and OB15, the highest amount of humus was recorded, which was accompanied by a great diversity of species at these points. By contrast, the lowest amount of organic matter was recorded at OB02, OB19, OB20, and OB21, which was due to the lower amount of species diversity and low percentage of projective cover (Figure 3).

The pH analysis showed that there is no soil with strong acidity in the study sites, but nevertheless, the lowest pH value was at point OB13; the soil pH was 7.34. A high level of alkalinity was noted at points OB19, OB20, OB21, and OB22. At other points, the alkalinity was closer to the standard average (Figure 4).

Soil saturation analysis showed that points OB06, OB08, OB10, OB14, OB18, OB21, and OB22 had the highest amount of salts, and points OB06 (10.212%) and OB22 (14.180%) had the most critical amount of salts. There was only one species, *Halostachys caspica* C.A. Mey, at both points (Figure 5).

According to the combined analysis, we can see the following results, where there is very strong salinity as on OB06; OB22 humus is less, but nevertheless it is present because, in these places, there were previously rice fields, which are now storages due to secondary salinization. Regarding pH and the sum of salts, the data of these two analyses are not compatible in our case (Figure 6).

The most interesting results appeared when interpreting the chemical composition of points and species that grew in the soil sampling sites. We considered only species of the Chenopodiaceae family. First, we analyzed the "Distribution of species by salinity degree" (Figure 7). Then, we analyzed "Distribution of species by type of salinity" (Figure 8). The following salts were present in the soil depth from 0 cm to 30-40 cm: CM: Calcium-Magnesium; CS: Calcium-Sodium; MC: Magnesium-Calcium; MS: Magnesium-Sodium; S: Sodium; SC: Sodium-Calcium; SM: Sodium-Magnesium; Su: Sulphate; Su+S: Sulphate with participation of Soda; ClS: Chloride-Sulphate; and ClSu+S: Chloride-Sulphate with the inclusion of Soda. The analysis of the obtained data indicates that, among 29 investigated taxa of the Chenopodiaceae family, only *Ceratocarpus utriculosus* is found in all presented soil types.

The growth of such species as *Salsola tragus*, *Caroxylon nitrarium*, *Kraschenінnikovia ewersmanniana*, and *Haloxylon aphyllum* was noted in three edaphic variants: sand-sand and loam-loam. Also, in three variants, loam-sand-loam-clay-clay species were noted: *Suaeda microphylla*, *S. altissima*, *Caroxylon orientale*, *Petrosimonia sibirica*, and *Climacoptera lanata*. Species occurring on sandy and sandy loam soil include *Xylosalsola arbuscula*, *Bassia lasiantha*, and *Atriplex dimorphostegia*. No species occurring only in sand were found during the research (Table 1).

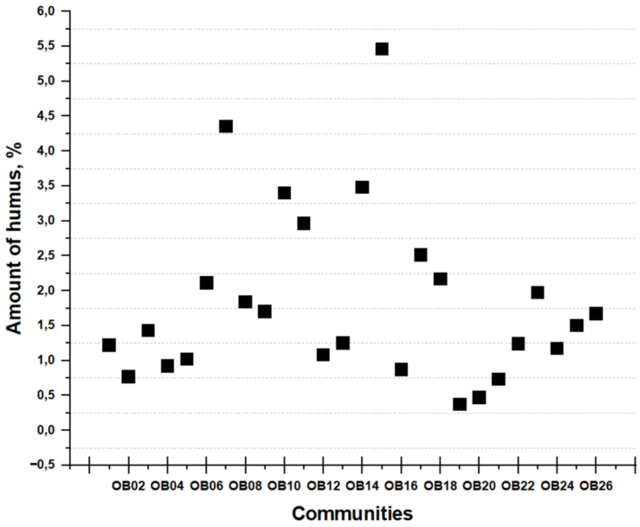

Figure 3. Percentage of humus in soil

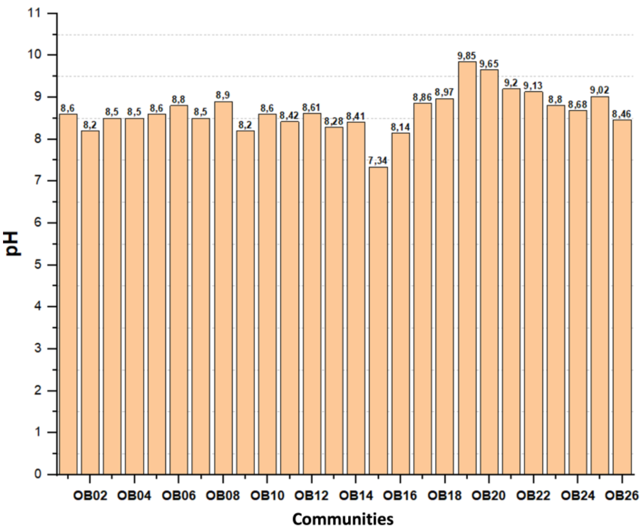

Figure 4. Soil pH data

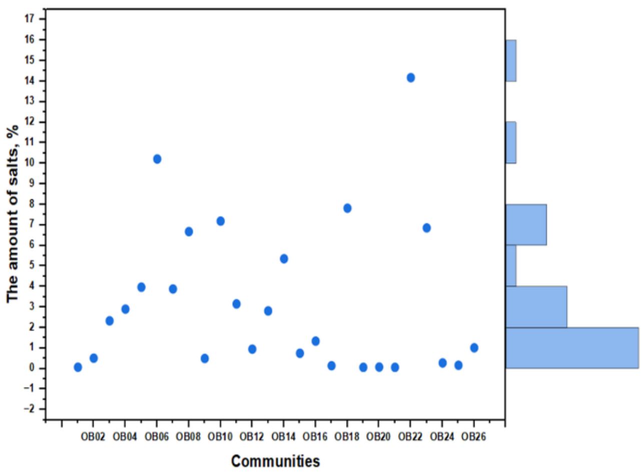

Figure 5. Amount of salt in soil

The greatest number of species (*Atriplex sagittata*, *Bassia odontoptera*, *Halocnemum strobilaceum*, *Kalidium caspicum*, *Kalidium foliatum*, *Salicornia europaea*, and *Suaeda acuminata*) was recorded on loamy and clayey soil. *Anabasis aphylla*, *Suaeda crassifolia*, *S. linifolia*, *Pyankovia brachiata*, *H. caspica*, and *Chenopodium album* grew on loamy substrate. Growth only on clay soil was recorded for *Atriplex tatarica* and *Climacoptera aralensis*.

The following species tolerate a wide range of salinization: *A. sagittata*, *B. odontoptera*, *C. lanata*, *H. aphyllum*, *K. ewersmanniana*, *P. sibirica*, and *S. microphylla*. However, species such as *A. sagittata*, *B. odontoptera*, *H. aphyllum*, and *K. ewersmanniana* prefer to settle on non-saline or slightly saline substrates. *C. lanata* and *P. sibirica* grow well in slightly and moderately saline soils. *S. microphylla* prefers strongly saline substrates. Therefore, the last three species can be referred to as salt-loving plants. *C. album* prefers non-saline habitats (Figures 4, 5, 6). The percentage of salt sum for non-saline soil in our study was 0.033%-0.174% (0.088±0.008%). *A. aphylla*, *A. dimorphostegia*, *B. lasiantha*, *B. prostrata*, *C. utriculosus*, *P. brachiata*, *C. nitrarium*, *C. orientale*, and *S. tragus* prefer non-saline and slightly saline soil (Figure 5).

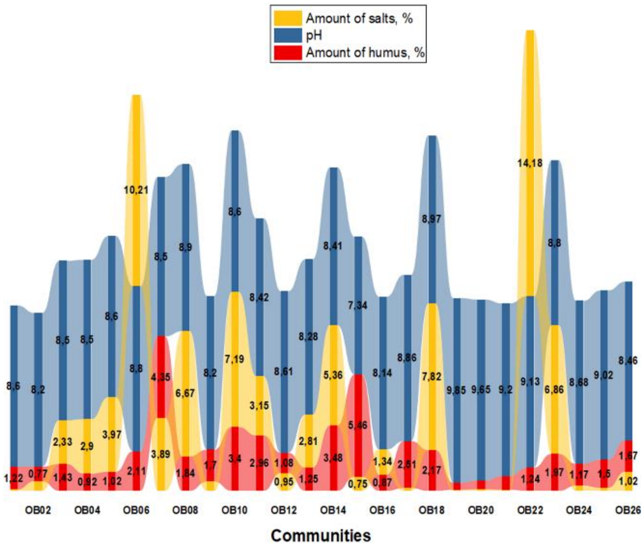

Figure 6. Combined results of soil analyses

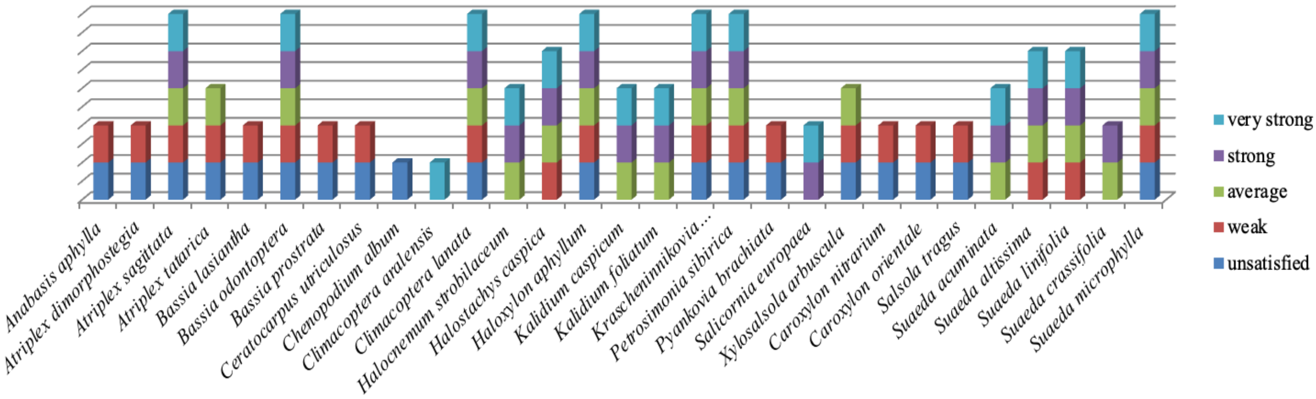

Figure 7. Distribution of species by degree of salinity

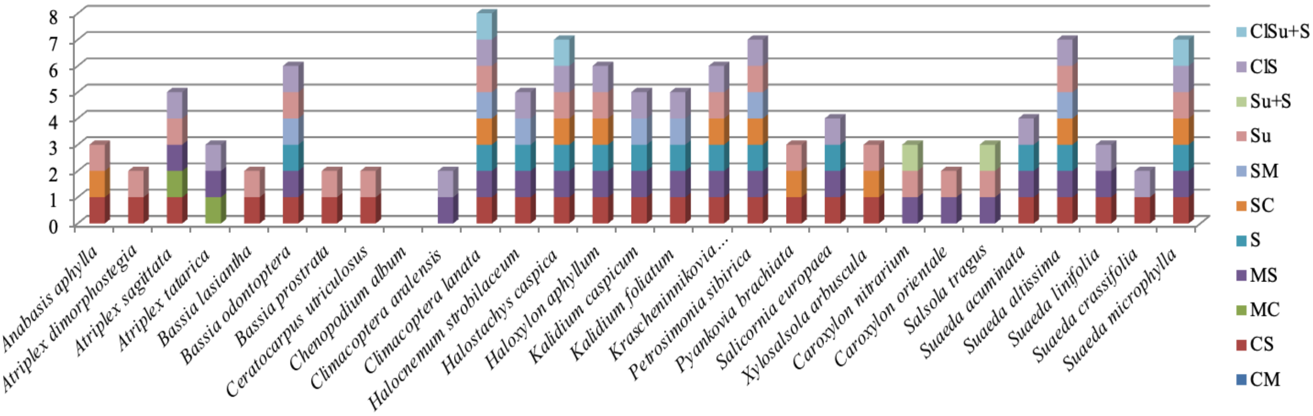

Figure 8. Distribution of species by salinity type

For slightly saline soil, the percentage index of the sum of salts according to our data is 0.186%-0.314% (0.262±0.017%), and for moderately saline soil, it was 0.493%-0.643% (0.555±0.026%). The percentage of salt sum for highly saline edaphic variants was 0.692%-2.165% (1.053±0.078%). *A. tatarica* and *X. arbuscula* occur in the diapason from non-saline to moderately saline soil, although they prefer non-saline variants, as populations of these species are usually depressed in saline soils. Populations of *S. altissima* and *S. linifolia* species prefer medium saline soil. *S. crassifolia* prefers medium to strong salinity, while *H. caspica* prefers strong to very strong salinity (Figures 4, 5, 6).

The percentage index of salt sum for very strongly saline soil, according to our data, corresponds to 2.281%-14.180% (4.089±0.665%). Strong and very strong soil salinization is preferred by *H. strobilaceum, K. caspicum, K. foliatum* and *S. acuminata*. Nevertheless, they are also found in places with medium salinity. However, species such as *S. europaea* are found only in highly and very highly saline soils (Figures 4, 5, 6).

Halostachys caspica, S. altissima, and *S. linifolia* occur on saline soils (weak to strongly saline). Species *H. caspica, H. strobilaceum, K. caspicum, K. foliatum,* and *S. europaea* can form monotypic communities in very highly saline areas.

Climacoptera lanata was the most adapted species, with a wide range of resistance to different salts (CS, MC, S, SC, SM, Su, ClS, ClSu+S). *P. sibirica, S. altissima, S. microphylla,* and *H. caspica* also have a wide range of adaptation to different types of salts (Figure 4). However, species such as *K. ewersmanniana, H. aphyllum, B. odontoptera,* and *A. sagittata*, though possessing a rather wide range of adaptability to different types of salts, prefer non-saline or slightly saline soil (Figure 7).

According to the literature data, the most widespread types of edaphic salinization include sulfate and chloride-sulfate solonchaks (which usually account for at least 37.9% and 35.3% of the total area of saline soils, respectively). Sulfate-chloride solonchaks follow them (22.2%). Less common are chloride-type solonchaks (2.2%), magnesian leaching (1.4%), and complex type (1%) (Yuan et al. 2019; Ivanov et al. 2020).

Regarding halophytic and hyperhalophytic edaphic variants in arid and semiarid regions, there is a significant diversity of representatives of the studied family Chenopodiaceae. The following group of species—*H. strobilaceum, K. caspicum, K. foliatum, S. europaea, S. acuminata*—tolerates a more limited range of salt diversity (CS, MS, S, SM, SSu). Nevertheless, they prefer to settle in places with higher concentrations in the soil.

Studies have shown that Calcium-Sodium (CS) salinity is the most widely represented in the study area. In the presence of this type of salinization in the soil, 23 out of 29 studied species were observed to grow there. Distribution by type of salinization showed that, in soils with Magnesium-Sodium (MS), there are 20 species, with Sulfate (Su), 19 species, and with Chloride-Sulfate (ClSu), 18 (Figure 7).

Two species (*A. sagittata* and *A. tatarica*) are confined to the Magnesium-Calcium (MC) type of salinization, which is rare in the study area. Also, one of the rare types of salinization is Chloride-Sulfate with the inclusion of Soda (ClSu+S). Of the species lists under consideration, *C. lanata, H. capsica,* and *S. microphylla* were recorded growing there. It should be noted that these three species are also well adapted to different types of land disturbances. Two species (*C. nitrarium* and *S. tragus*) are also found on soils with Sulfate salinization involving Soda (Su+S).

Various ways have been developed to rehabilitate saline soils, which are categorized into hydraulic, physical, chemical, and biological methods. Biological methods include organic fertilization, crop rotation, salt-tolerant crops, and plant bioremediation (Krupskaya et al. 2022; Rahimova et al. 2023). The latter method is also referred to as phytoremediation, plant bioremediation, or desalination of salt-affected soils using plants. This plant-based method is of great importance, especially for a number of developing countries where chemical additives are becoming more and more expensive. According to Qadir and Oster (2004), plant bioremediation is considered a function of four main factors: (i) partial pressure of CO2 in the root zone; (ii) proton release in roots in the case of N2-fixing legumes; (iii) physical effects of roots in improving salt leaching; (iv) Na+ accumulation in shoots.

Many researchers on this issue believe that phytoremediation of solonetz soils is mainly based on leaching. However, on poorly drained saline soils, especially in arid and semi-arid regions, where rainfall is too low to leach salts from the rhizosphere (Rahimova et al. 2023), sodium accumulation in shoots in the process of bioremediation is of great importance. In this regard, Zhao et al. (2005) and Ravindran et al. (2007) called for the use of plants with Na+ and Cl- hyperaccumulation for soil desalinization.

In conclusion, the analysis of the obtained data indicates that at least four groups can be distinguished among the studied species in terms of preference to one or another degree of soil salinity: 1) species confined to non-saline and slightly saline soils (*A. aphylla, A. dimorphostegia, B. prostrata, C. utriculosus, C. album, P. brachiata, C. nitrarium, C. orientale, S. tragus*); 2) species preferring slightly and sometimes moderately saline soil (*A. sagittata, A. tatarica, B. odontoptera, H. aphyllum, K. ewersmanniana, X. arbuscula*); 3) species confined to medium and highly saline substrates (*C. lanata, P. sibirica, S. altissima, S. linifolia, S. crassifolia*); and 4) species preferring strongly and very strongly saline soils (*H. caspica, H. strobilaceum, K. caspicum, K. foliatum, S. europaea, S. acuminata, S. microphylla*). Distribution of studied taxa on preference to one or another degree of salinity at genus level also showed certain peculiarities. In particular, it was revealed that species of genera *Atriplex, Caroxylon,* and *Bassia* grow, as a rule, on soils from non-saline to slightly saline. In turn, species of *Suaeda* genus prefer to settle on medium and highly saline soils. Finally, species being hyperhalophytes (preferring a high degree of salinity) belong exclusively to one subfamily, Salicornioideae. This indicates a certain direction of evolution of the adaptive characteristics of representatives of this family. Also, we propose to use annual species of the Chenopodiaceae family for plant bioremediation (phytoremediation) of disturbed and saline lands in desert regions (*S. europaea, S. acuminata, S. altissima, S. linifolia, S. crassifolia, C. lanata, P. sibirica*).

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