Journal of Life Sciences & Biomedicine, vol. 6(79), No 2, p. 102-113 (2024)

The problems of desertification of soil-plant cover as consequences of climate change

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Received: September 30, 2024; Received in revised form: November 25, 2024; Accepted: December 18, 2024

An analysis of botanical groups, the composition of associations and formations of desert and semi-desert vegetation and soil cover of the flat part of the Shirvan zone of Azerbaijan was carried out during the research. The state of soils and plant species composition of associations were established. Saline soils are developed in semi-deserts on the Shirvan plain under dry subtropical climatic conditions. The desert vegetation type of the Shirvan territory is zonal in nature and is formed by 2 formation classes, 6 formations and 19 associations, and the semi-desert vegetation of the Shirvan territory is formed by 3 classes, 3 formations and 9 associations were revealed as a result of the research.

Keywords: *Desert, semi-desert, aridization, climate change, vegetation and soil cover*

INTRODUCTION

Desertification is the degradation of “land” in arid and semi-arid regions of the globe, caused by both anthropogenic and natural factors and processes. The concept of "land" in this case means a bioproductive system consisting of soil, water, vegetation and other biomass, as well as ecological and hydrological processes within the system (Description, Causes, & Impact…..). Now, the world is facing an acute problem of aridization, that is the advance of the desert, as a consequence of which there is a decrease in biomass, productivity, and species diversity as a result of targeted climate change or intensive economic activity. These vulnerable ecosystems are important with unique features and resources. They include deserts, semi-arid soils, mountains, wetlands, small islands and some coastal areas. Destruction of vegetation due to lack of energy, intensive grazing, inadequate irrigation systems, unregulated farming, poor agricultural practices and other causes accelerate the desertification process. The process of various types of desertification is taking place on 3,741 thousand hectares of the territory of the republic (National Atlas of Azerbaijan, 2016). The main reasons for this are water erosion (34.3%), irrigation erosion (3.2%), wind erosion (4.3%) (National Atlas of Azerbaijan, 2016). This process has accelerated in recent decades in the Kur-Araz lowland, the Absheron Peninsula and the territory of the Nakhchivan Autonomous Republic, which have an arid and semi-arid climate and where agriculture is most developed. As a result, the lands subject to desertification have reached a size of 36% to 43.3% (3,741 thousand hectares) in the last 30 years (Gasimzade, 2015). So, a desert is a zonal type of landscape that has developed under conditions of moisture deficiency (arid desert) or heat (cold desert) and is characterized by the sharp amplitude of daily and annual air temperatures, favorable for plant development. 23% of the earth's surface is classified as typical deserts according to updated UNESCO data (UN Convention, 1994). The desert is considered a characteristic type of Eastern Transcaucasia. There is also the concept of "semi-desert", which is a transition from the

https://doi.org/10.59849/2710-4915.2024.2.102
Available online 31 December 2024

desert to the steppes.

If earlier the concepts of "semi-desert" and "desert" characterized only the landscape, then recently it is also understood as the plant types common in the territory. Thus, these concepts have a dual nature and are accepted as landscape-geographical (regional) and geobotanical terms (www.britannica.com). Deserts and semi-deserts have an excessively dry climate, saline and solonchak soil cover from a geographical point of view. The soil contains various salts in significant quantities. The amount of sand in the soil is greater. The average annual precipitation is low. The average air temperature is high. The abundance of the thermal effect in the desert and the low level of atmospheric moisture depend not only on zonal climate changes, but also on the nature of the substrate, the nature of moisture, water permeability, and the absorption of water from the air. Therefore, the nature of the substrate plays an important role in the formation of the desert. Most researchers classify deserts and semi-deserts as areas where the natural selection of life forms is developed in drought resistance (Smolander, 2005).

MATERIALS AND METHODS

The natural and geographical landscapes of the Gobustan, Hajigabul, Kurdemir, Ujar, Zardab, Goychay, Agdash, Yevlakh, Akhsu districts of the Shirvan territory of Azerbaijan were chosen as the object of study. Research methods: expeditions, semi-stationary and office stages and laboratory studies. The soil-vegetation of the studied territory was classified and geobotanical descriptions were selected for ecobiological analysis (Yaroshenko, 1961, 1969; Beideman, 1960; Haciyev, Gasimova, 2008). The studies were conducted under field route conditions with GIS coordinates indicated. The materials of the Flora of the USSR (Flora of the USSR, 1934-1960), the Caucasus (Grossheim, 1950), Azerbaijan (Flora of Azerbaijan 1950-1961), modern literary and internet catalogues, as well as a number of other sources were used under identifying the species. Number of standard methods were used in the course of geobotanical studies, when studying the current state of the species population and assessing the cenopopulation: accordings to V.A.Yurtsev (Yurtsev, 1975), and to R.V.Kamelin (Kamelin, 1973). The abundance of vegetation in the formation is given according to the five-point system of A.A.Grossheim (Grossgeim, 1932), the phenological phases of vegetation in the species composition of the formation are indicated in the following order: veg. - vegetation; flow. - flowering, fruit. - fruiting (Beideman, 1960).

RESULTS AND DISCUSSION

Semi-deserts extend to an altitude of 1000 (1100) – 1300 (1600) m a.s.l. The main factors influencing semi-desert vegetation are moisture deficit, high summer temperatures and soil salinization. The amount of annual precipitation in the semi-desert zone does not exceed 200-300 mm. Precipitation occurs in the spring and autumn periods. Ephemeral plants develop and enrich the forage quality of winter pastures during this period. The dry period lasts 4-5 months here. Saline soils are developed in semi-deserts on the Shirvan plain under dry subtropical climatic conditions. Saline soils are mainly distributed as spots with different contours in the area of zonal meadow-steppe and gray-brown soils and cover 1.3%-1.5% of the territory. As a rule, saline soils are distributed in low parts, close to the surface of the level of saline groundwater, or in most cases, in depressions protruding to the surface. Samples of this type were taken in the Hajigabul district (samples were taken on the territory of the urban municipality of Hajigabul, arable land, longitude 48º52′33″, latitude 40°3′22″) at depths of 0-18,18-68,68-108, 108-141, 141-186 cm.

Soil moisture is within 3.9%. Humus content is very low, in the upper layers – 1.90%, in the lower layer it decreases to 0.48%. Carbonate content in the upper and lower layers is 14-15%, in the middle layers it increases to 17.9%. The sum of absorbed bases increases from 24.85 to 39.15 from the upper to the lower layer, respectively. According to the granulometric composition, at <0.001, the upper layer indicator is 9.88, in the second layer - 11.00, in the third and fourth 10.44 and 10.22,

respectively, and in the lower layer it decreases to 9.94, and at <0.01, the values by layers in the first are 33.58, in the second - 37.60, in the third - 35.68, in the fourth - 38.50, in the lower layer - 32.52, respectively.

The flat part of the territory is classified as clayey desert and semi-desert types according to general physical and geographical conditions. The soils of saltwort deserts are, in most cases, solonchaks, and form a transition to zonal gray-brown desert soils (Gasimzade and Ibadullayeva, 2015; Gasimzade, 2015).

Such complex ecological conditions lead to the development of plant groups with a simple composition in semi-deserts. Simple semi-desert formations are replaced by more complex semi-desert wormwood groups in the western and south-western parts, with relatively high humidity, as a result of improved soil conditions. After the end of the vegetation period of ephemerals in May, perennial plants, especially subshrubs and shrubs, begin to develop in semi-deserts. Perennial plants, especially subshrubs and shrubs, begin to develop in semi-deserts after the end of the vegetation period of ephemerals in May. The most common are of the cereals: *Poa pratensis* L., *Bromus japonicus* Thumb., *Lolium rigidum* Gaud., *Eremopyrum orientale* (L.) Jaub.&Spach., *E.triticeum* (L.) Jaub.&Spach., *Agropyron cristatum* (L.)Gaertn., and also *Plantago ovata* L., *Silybum marianum* L., *Calendula arvensis* L.

So, semi-desert vegetation is widespread in the central part of Shirvan (at the foot of the Lesser Garamin Range).

To the north of the Kura river, close to the mountain foot, semi-desert vegetation forms a wide strip parallel to the Kura river, i.e. desert vegetation is replaced by semi-desert, which depends on the degree of salinity of the upper soil layer and on the relief. Desert phytocenosis is found in convex and semi-desert phytocenoses - in hollow relief.

From the left bank to the foot of the mountain on the convex parts of the relief, white wormwood joins the caragana thickets, where the botanical content of ephemeral synusia increases and tiers are formed, resulting in the formation of wormwood-saltwort-ephemeral phytocenosis.

On the convex part of the relief, as a result of the decrease in the degree of salinization of the upper soil layer (0-20 cm), caragana leaves the wormwood-saltwort-ephemeral phytocenosis and forms a wormwood-ephemeral phytocenosis. The wormwood-ephemeral phytocenosis predominates as a result of the decrease in the degree of salinization of the upper soil layer. Classification of semi-desert vegetation in the research area:

Type: Semi-desert

I. Formation class: *Salsola wormwood*

Formation: *Salsoleta – Artemisietum*

Association:

1. *Artemisia fragranso – Salsola dendroidesum*
2. *Artemisia fragranso – Salsola nodolosum*
3. *Artemisia fragranso – Climacoptera crassosum*
4. *Artemisia fragranso – Petrpsimonia brachiatosum*

II. Formation class: *Ephemerality*

Formation: *Hordetum*

Association:

1. *Hordeum leporinumoso – Lolium rigidiumosum*

III. Formation class: Epherality-wormwood

Formation: *Artemisietum*

Associations:

1. *Artemisia fragransum*
2. *Artemisia fragranso – herbosum*
3. *Artemisia fragranso – Ephemerotosum*
4. *Artemisia fragranso – Tripleurospermum perforatosum*

The woody saltwort-wormwood formation covers the slightly saline soils of the study area. The edificatory of the formation is white wormwood (*Artemisia lerchiana* Web.)– perennial plant, height (25) 30-45 cm. The formation is represented by 4 associations in the area *Artemisia lerchianoso – Salsola dendroidososum*; *Artemisia lerchianoso – Salsola nodulososum*; *Artemisia lerchianoso – Climacortera crassosum*; *Artemisia lerchianoso – Retrosimonia brachiatosum.*

The edificatory of the *Salsola arborescens – Artemisia alba* association is a subshrub – *Artemisia alba* Turra, the dominant is *Salsola arborescens* L.

The association includes 22 species, which

cover 12 families (*Chenopodiaceae, Roaceae, Fabaceae, Asteraceae, Alliaceae, Geraniaceae, Malvaceae, Papaveraceae, Apiaceae, Ranunculaceae, Fumariaceae, Scrophulariaceae*).

The following families predominate in terms of the number of species: *Rosaceae* – 5 species, *Asteraceae* – 4, *Fabaceae* – 3, *Chenopodiaceae* – 2. The remaining 8 families are represented by 1 species.

There are 4 tiers in the association. In the first tier – *Salsola dendroides* Pall. with an abundance of 2 and an average height of 50 cm. the dominant of the association. *Artemisia lercheana* Weber. (some authors note as *A.arenaria* DC. but in the world flora online *A.lercheana* Weber.) is located in the second tier with an abundance of 3, an average height of 30 cm. This tier also includes *Salsola nodulosa* Iljin. In the third tier with an abundance of 1-2, an average height of 9-25 cm are located from ephemerals and ephemeroids - *Poa bulbosa* L., *Aegilops triuncialis* L., *Lolium rigidum* Gaudin, *Alhagi pseudoalhagi* (Bieb.) Fisch., *Allium affine* Ledeb., *Gagea tenufolia* (L.) Ker Gawl., *Adonis bienertii* Butkov, *Papaver phoeas* L. etc. The fourth tier is represented by lichen – *Parmelia vagans* (Nyl.) Hale, and moss – *Barbula unguiculata* Hedw.

Grey soils rich in $CaCO_3$ are developed on the convex parts of the relief in the area of the ephemeral wormwood phytocenosis study.

The formation has been presented by 4 associations: *Artemisetum–Herbosum*; *Artemisetum–Erhemersoum*; *Artemisetum-Salsosum, Artemisetum-Petrosimonosum.*

The floristic composition of the ephemeral-white wormwood association includes over 30 species, which cover 16 families: *Asteraceae, Poaceae, Scrophulariaceae, Fabaceae, Apiaceae, Liliaceae, Amaryllidaceae, Iridaceae, Ranunculaceae, Fumariaceae, Hypecoaceae, Brassicaceae, Frankeniaceae, Geraniaceae, Plantaginaceae, Chenopodiaceae*. The most common species are *Poaceae* – 7, *Asteraceae* – 5, *Scrorhulariaceae* – 3 species, *Apiaceae* и *Fabaceae* families have presented by 2 species, other 11 families by 1 species. The species composition of the *Artemisia lerchianoso – Efemeretosum* association (Fig.1) with the participation of the dominant *Artemisia arenaria* DC. is given in Table 1.

Fig. 1. *Artemisetum–Erhemersoum*

Table 1. The species composition of the association *Artemisetum – Herbosum*

Species	Abun-dance	Tiers height (in cm)	Phenological phase April-May
1	**2**	**3**	**4**
Subshrub			
Salsola dendroides	2	I (35 cm)	veg.
Semi-bushes			
Artemisia lerchiana	3	I (32 cm)	veg.
Cereals			
Poa bulbosa	1-2	II (17 cm)	flow.-fruit.
Hordeum lerorinum	1	II (19 cm)	flow.
Bromus yaponicus	1	II (15 cm)	flow.
Lolium rigidum	1-2	II (20 cm)	fruit.
Anisantha rubens	1	II (20 cm)	fruit.
Aegilors cilindrica	1	II (22 cm)	flow.
Eremopyrum triticeum	1	II (16 cm)	flow.-fruit.
Legumes			
Vicia cinerea	1	II (20 cm)	flow.- fruit.
Medicago minima	1	II (10 cm)	flow.- fruit.
Motley-grass			
Gagea tenuifolia	1	II (12 cm)	flow.- fruit.
Allium rubellum	1	II (12 cm)	flow.- fruit.
Iris acutiloba	1	II (10 cm)	flow.
Adonis aestivalis	1	II (25 cm)	flow.
Fumaria schleicheri	1	II (20 cm)	flow.-fruit.
Hypecoum pendulum	1	II (20 cm)	flow.- fruit.
Strigosella africana	1	II (12 cm)	fruit.
Parentucella latifolia	1	II (14 cm)	flow.- fruit.
Veronica rolita	1	II (7 cm)	flow.-fruit.
V. amoena	1	II (10 cm)	flow.-fruit.
Calendula persica	1	II (9 cm)	fruit.
Tragorogon graminifolius	1	II (21 cm)	flow.
Tripleurospermum perforatum	1	II (12 cm)	veg.
Plantago ovata	1	II (6 cm)	flow.-fruit.
Scandix pecten – veneris	1	II (17 cm)	flow.-fruit.

Continued table 1

1	2	3	4
Torilis nodosa	1	II (20 cm)	flow.
Frankenia rulverulenta	1	II (10 cm)	flow.
Erodium cicutarium	1	II (25 cm)	flow.-fruit.
Scorzonera laciniata	1	II (20 cm)	flow.
Strigosella africana	1	I (15 cm)	flow.-fruit.
Calendula persica	1	I (10 cm)	flow.-fruit.
Sonchus oleraceus	1	I (40 cm)	flow.

The vegetation is formed from xeromesophytes and xerophytes that evident from the species composition of this phytocenosis. White wormwood is a xerophyte, and ephemerals and ephemeroids are xeromesophytes. Cereals are represented here by 8 species, legumes by 3 species, and motley grass by 19 species. Hence the conclusion that motley grass predominates in the phytocenosis.

Analyzing this phytocenosis by life forms, it turns out that annuals are represented by 20 species, biennials by 3 species, and perennials by 10 species. The total projective cover of the phytocenosis is 60-80%, of which 25-40% is organized from edificator wormwood, 20-30% from subedificators, 10-15% from ephemerals and ephemeroids.

Two-tier ephemeral phytocenosis is developed on the convex part of the relief of the studied territory. The floristic composition of the formation includes 25 species belonging to 12 families in spring (in the last decades of April) (*Poaceae, Fabaceae, Asteraceae, Brassicaceae, Ranunculaceae, Geraniaceae, Scrophulariaceae, Apiaceae, Plantaginaceae, Paraveraceae, Hypecoaceae, Boraginaceae*). Families predominate in terms of the number of species: *Poaceae*–6 species, *Asteraceae* – 4, every from *Fabaceae, Brassicaceae, Geraniaceae, Ranunculaceae* families by 2 species, other 7 families - monospecies.

The dominant species in the phytocenosis are members of the *Poaceae* family. However, the dominant species in the phytocenosis can be replaced depending on annual and seasonal precipitation. The formation has two tiers. The first tier (with an average height of 20-30 cm) is organized from ephemerals and ephemeroids. This tier includes *Poa bulbosa* L., *Lolium rigidum* Gaudin., *Sisymbrium runcinatum* Lax. ex DC., *Plantago lanceolata* L., *Veronica amoena* L., *Calendula persica* L., second tiers (below 1cm) organized from mosses (*Barbula unguiculata sp.* Hedw.) and lichens *Parmelia vagans* (Nyl.)Hale. The formation is represented by annuals - 23 species, and perennials - 3 species according to life forms. Ephemerals and ephemeroids also play a significant role in the formation of desert vegetation (Fig. 2).

Fig. 2. Wormwood - ephemeral semi-desert fragment

The main forage reserve of winter pastures is ephemeral. Among them are very valuable forage plants related to legumes, cereals and motley grass. Changes in the amount of these species are associated with seasonal rains. It can be concluded that the semi-desert vegetation of the Shirvan territory is formed by 3 formation classes, 3 formations and 9 associations.

Below are the classification schemes of desert vegetation of the study area:

Vegetation type: Desert

Formation class: *I* – Annual swede and saltwort

Formation: *Suaedietum*

Association :

1. *Suaeda confusoso – Petrosimonia brachiatosum*

2. *Suaeda confusosum*

Formation: *Salicornetum*

Association:

1. *Salicornia europerosa – Suaeda confusosum*

2. *Salicornia europerosum*

Formation: *Petrosimonietum*

Association:

1. *Petrosimonia brachiatoso – Climactera crassosum*
2. *Petrosimonia brachiatoso – Suaeda confusosum*
3. *Petrosimonia brachiatoso – Salsola dendraidesosum*
4. *Petrosimonia brachiatosum*

Formation: *Climacopteretum*

Association:

1. *Climactera crassosum*
2. *Climactera crassososo – Petrosimonia brachiatosum*

Formation class: *II – shrubs, bushy sweda and saltwort*

Formation: *Suaedetum*

Association: *Suaeda microphyllosa – Petrosimonia brachiatosum*

Formation: *Salsoletum*

Associations formed by the *Salsola nodulosa* (Moq.) Iljin and *Salsola dendroides* Pall. species are found in areas belonging to the *Salsola* L. genus:

Association:

1. *Salsola nodulososum*
2. *Salsola nodulososo – Ephemeretosum*
3. *Salsola nodulososo – Petrosimonia brachiatosum*
4. *Salsola nodulososo – Artemisia fragransosum*

Association:

1. *Salsola dendroidesoso – Ephemeretosum*
2. *Salsola dendroidesoso – Alhagi pseualhagiosum*
3. *Salsola dendroidesoso – Petrosimonia brachiatosum*
4. *Salsola dendroidesoso – Artemisia fragransosum*
5. *Salsola dendroidesoso – Halostachys belangerianum*.

Suaedetum formation. This formation is typical for desert vegetation, common in saline soils, forms an independent grouping, participates in saltwort semi-deserts and deserts. However, in comparison with other formations, it is not widespread. The edificatory of the formation is *Suaeda microrhylla* Pall. The formation has been presented by 1 association:

Suaeda microrhylloso - Petrosimonia brachiatosum (Fig. 3). The association includes shrubs, subshrubs, subbushes, cereals and motley grass, of which 10 species are annual and 4 species are perennial. The total projective cover is 40-50%.

Suaeda microrhylla Pall. dominated by 2-3 abundance in the first tier, with an average height of 60 cm. Also participating in this tier is *Tamarix ramosissima* Ledeb. – abundance 1, with an average height of 100 cm. In the second tier, there are 1-2 abundant cereals and motley grass with a height of 10-40 cm: *Bromus japonicus* Thunb., *Petrosimonia brachiata* (Pall.) Bunge, *Suaeda confusa* L., *Malvalthaea transcaucasica* L., *Torilis nodosa* (L.) Gaertn, etc.

Fig. 3. *Suaeda microrhylla* Pall.- *Petrosimonia brachiata* (Pall.) Bunge

Lichens *Fulgensia fulgeus* are noted on the soil surface, from mosses – *Barbula unguiculata* hedw.

The species composition of the association *Petrosimonium ramosa – Sueda microphylla* is given in the following table with the participation of the dominant species *Suaeda microphylla* (Table 2).

Valuable forage plants are well eaten by sheep and cattle (*Anisantha rubens*, *Bromus japonicus* Thunb., etc.) on winter pastures, included in the formation, flowering in early spring.

Salicornietum formation. Halohyrophilic vegetation is widespread and found in pure and mixed phytocenosis of the saltwort formation in the wet saline depressions of the study area. We collected saltwort in the wet saline areas of the Garasu and Padar villages.

The dominant of the formation is –

Salicornia europeae L. (Fig. 4). *Climacopteretum* formation covers a wide area of the desert. It is distributed mainly in saltwort and saline soils. The dominant plant of the formation is the annual plant *Climacoptera crassa* (Bieb.) Batsch.

Table 2. Species composition of the *Suaeda mycrophylloso – Petrosimonia brachiatosum* association

Species	Abundant	Tiers height (in cm)	Phenological phase April-May
Shrubs			
Tamarix ramosissima	1	I (100 cm)	veg.
Bushes			
Suaeda microphylla	3	II (30 cm)	veg.
Anabasis aphylla	1	II (20 cm)	veg.
Subshrubs			
Salsola dendroides	1	II (40 cm)	veg.
Cereals			
Hordeum leporinum	1	II (17 cm)	flow.
Anisantha rubens	1	II (10 cm)	fruit.
Bromus japonicus	1	II (17 cm)	fruit.
Motley grass			
Petrosimonia brachiata	2	II (14 cm)	veg.
Suaeda confusa	2	II (12 cm)	veg.
Torilis nodosa	1	II (11 cm)	flow.-fruit.
Lagoserus glaucescens	1	II (8 cm)	flow.
Malvalthaea transcaucasica	1	II (9 cm)	flow.

Fig. 4. *Salicornia europeosum* L.

The association is represented by 22 species: 18 species are annual and biennial, 4 species are perennial. The projective cover is 30-40% (Fig. 5). The formation is characterized by a sparse grass cover, which is the reason for the poorly developed tiring in them.

Salsoletum formation is formed in different ecological conditions, in arid subtropical regions resistant to salinization, drought and heat, in most cases on saline rocks and is widespread in the foothills of the sole, according to the mechanical composition and it is formed in heavy, saline, dry soil.

Fig. 5. *Climacoptera crassa* (Bieb.) Batsch.

The edificatory of the formation is - *Salsola nodulosa* (Moq.) Iljin. The formation of *Salsoletum nodulosae* L. can be considered as a genetic stage developing in saline soils from the point of view of differentiation of soil horizons replacing each other and decomposition of salts.

However, recent studies have proven that in the central part of the territory of Shirvan, as well as in the ecosystem we are studying, the *Salsoletum* formation dominates in different ecological conditions and is represented by the 4 associations.

The mentioned ephemeral-gengis association is represented by 23 species. In the first tier there is an abundance of 3, dominant gengiz (*Salsola nodulosa* L.), with an average height of 28 cm. In the second tier there are an abundance of 1-2 - *Phalaris brachystachis* Link, *Avena eriantha* Durieu, *Hordeum lerorinum* L., etc., medium height 10-17 cm, motley grass: with abundance 1-2 *Allium rubellum* M.Bieb, *Tripleurospemum perforatum* L., *Torilis nodosa* (L.) Gaertn., etc., medium height 7-15 cm. The total projective cover is 30-50% (Fig.6).

Independent groupings on the territory are organized from ephemerals (pure or mixed), growing among gengiz shrubs of the gengiz layer and form gengiz semi-deserts.

Intensive development of ephemerals and ephemeroids begins, which gives the cenosis a special beauty after winter hibernation, in early spring, due to precipitation.

Due to aridity, in summer, aspects of the cenosis change. Thus, at the end of May, due to the withering of ephemerals and ephemeroids, the soil cover is exposed. As a result, the gengiz grouping is painted in a gray-green flow. Gengiz bears fruit and gives the cenosis a grey-reddish background in autumn. The grey becomes livelier by the end of autumn, ephemerals and ephemeroids turn green due to precipitation, and in winter, due to frosts, development is suspended.

Fig. 6. *Salsola nodulosa* (Moq.) Iljin

This means that the aspect of the gengiz formation is determined in development together with ephemerals and ephemeroids in spring, edificatory gengiz in summer, gengiz and perennials in autumn, ephemerals and ephemeroids in winter.

Salsoletum formation is a characteristic plant grouping for the study area, growing in a species composition saline to varying degrees on gray and gray-meadow soils.

The edificatory of the formation is *Salsola dendroides* Rall. Representatives of vegetation of different life forms, groups, forming the composition of the flora of the caragana formation: shrubs – *Halostachys belangeriana* (Moq.) Botsch., *Tamarix ramossima* Ledeb., *Lucium ruthenicum* Murray; bushes – *Salsola nodulosa* (Moq.) Iljin, *Kalidium capsicum* Moq., *Suaeda microphylla* (Pall.) C.A.Mey.; subshrubs and subbushes – *Salsola dendroides* Pall., *Camphorosma lessinqii* Litvinov, *Halocnemum strobilaceum* (Pall.) M.Bieb., *Artemisia fragrans* Willd., *Atriplex turcomanica* (Moq.) Boiss.; perennial herbs – *Aeluropus repens* (L.) Thwaites, *Ae. tittoralis* (gouan) Parl. *Limonium scoparium* (Pall. Ex Willd.) H.Arnaud, *Alhagi pseudoalhagi* (m.Bieb.)Desv. Ex Wangerin, *Cynodon dactylon* (L.)Pers.; ephemeroids – *Poa bulbosa* L., *Allium rubellum* M.Bieb; summer-autumn vegetation – *Climacoptera crassa* (M.Bieb) Botsch, *Gamanthus pilosus* (Pall.) Bunge., *Salsola soda* L., *Petrosimonia brachiate* (Pall.) Bunge, *Suaeda altissima (*L.)Pall, *S. confuse* Iljin; ephemers – *Anisantha tectorum* (L.) Nevski (*Bromus tectorum* L.), *Bromus yaponicus* Thunb., *Hordeum leporinum* L., *H. geniculatum* All., *Phleum paniculatum* Huds, *Lepidium perfoliatum* L., *Limonium spicata* Mill., *Eremopyrum orientale* (L.) Jaub. & Spach., *E.triticeum (*Gaertn.)Nevski, *Adonis aestivalis* L., *Filago spathulata* C.Presl., *Hernaria hirsute* L., *Erodium ciconium* (L.) Her., *Aegilopus squarrosa* L., *A.cylindrica* Host, etc.

In most cases, caragana and wormwood have the same abundance and accompany each other. Two types of mixed wormwood-caragana associations are formed as a result of the merger of the caragana and wormwood deserts. Wormwood is a stronger edificatory, and therefore, displacing caragana to the foothills of the mountains, it replaces it and turns first into a caragana-wormwood, and then into a purely wormwood association. This means that despite the fact that caragana formations have existed in the area for many hundreds of years, they are replaced by wormwood deserts in the process of natural development. Therefore, caragana deserts are considered a transition to a wormwood desert. All varieties of the caragana desert flora of the Kura-Araz Lowland are formed from 82 species of higher plants, most of which belong to the *Poaceae, Chenopodiaceae, Asteraceae* families, etc. (16). One of the characteristic features of caragana deserts is the presence of cereal ephemerals. The species composition of the formation includes glycophytic and halophytic ephemerals.

Glycophytic cereal ephemerals and ephemeroids are found in the least saline soils: *Anisantha rubens* (L.) Nevski, *Hordeum leporinum* L., *Lolium rigidum* Gaudin., *Poa bulbosa* L., etc. Halophytic elements are found in the most saline soils: *Eremopyrum orientale* (L.) Jaub. & Spach., *Plantago loflingii* L., etc. Ephemerals usually form a tier with an average height of 8-14 cm. 5 associative groups have been established in the composition of the caragana association depending on the relief features, high soil salinity, high temperature, low humidity: associative group of caragana with annual saltworts (trichohydrophytes); associative group of caragana with perennial herbs, subshrubs and shrubs (phreatophytes); associative group of caragana with ephemerals and ephemeroids (ambrophytes); associative group of caragana with subshrub saltworts (phreatophytes, trichohydrophytes, ambrophytes); associative group of caragana with subshrub wormwoods (ambrophytes).

A wide area is occupied by wormwood-caragana, saltwort-caragana and ephemeral-caragana associations among the indicated groups. The association formed by caragana with ephemerals, ephemeroids is not widespread in the study area and occurs in the form of spots. The association is widespread on gray-brown, saline- gray soils. The species composition of the ephemeral-caragana association with the participation of the dominant *Salsola dendroides* Pall. (Fig. 7) is given in the table below (Table 3).

Fig. 7. *Salsola dendroides* Pall.

The association includes 21 species: subshrubs – 1, cereals – 6, motley grass – 14 species. Of these, annuals and biennials are represented by 18 species, perennials – by 3 species. The total projective cover is 40-60%. *Salsola dendroides* Pall. association edificatory - the first tier is abundantly filled with 3, height 40cm. The second tier is made up of ephemerals-ephemeroids with an abundance of 1-2 - *Lolium rigidum* Gaudin., *Hordeum leporinum* Link, *Bromus yaponicus* Houtt height 14-22 cm; and from the motley grasses with an abundance of 1 and a height of 12-30 cm the following predominate - *Stellaria media* (L.) Vill., *Adonis aestivalis* L., *Sisymbricum loeselii* L., *Medicago minima* (L.) L., *Geranium pusillum* L., *Erodium cicutarium* (L.) L.Hier., etc. In the last tier on the soil surface there are lichen – Nyl.) Hale, and moss – *Barbula unguiculata* Hedw. (Table 3).

Table 3. Species composition of the *Salsoleta dendroideso – Ephemeretosum* association

Species	Abundant	Tiers height (in cm)	Phenological phase April-May
Subshrubs			
Salsola dendroides	3	I (45 cm)	veg.
Cereals			
Poa bulbosa	1-2	II (17 cm)	flow.-fruit.
Anisantha rubeus	1-2	II (18 cm)	fruit.
Lolium rigidum	1-2	II (15 cm)	flow.
Bromus japonicus	1	II (19 cm)	flow.
Hordeum leporinum	1	II (20 cm)	flow.-fruit.
Phleum raniculatum	1	II (22 cm)	flow.
Motley grass			
Petrosimonia brachiata	1	II (16 cm)	veg.
Geranium rusillum	1	II (17 cm)	flow.
Erodium cicutarium	1	II (25 cm)	flow.-fruit.
Sisymbrium loeselii	1	II (28 cm)	flow.
Adonis aestivalis	1	II (30 cm)	flow.
Stellaria media	1	II (14 cm)	flow.
Medicago minima	1	II (12 cm)	Цвет
Leridium vesicarium	1	II (16 cm)	flow.-fruit.
Trirleurospermum perforatum	1	II (19 cm)	flow.-fruit.
Strigosella africana	1	II (18 cm)	flow.-fruit.
Malva neglecta	1	II (20 cm)	flow.
Anagallis arvensis	1	II (13 cm)	flow.
Scandix pecten – veneris	1	II (20 cm)	fruit.
Parentucella latifolia	1	II (13 cm)	flow.-fruit.

The association formed by caragana with

subshrub wormwoods (ombrophytes) is relatively common in foothill areas, in gray-brown, slightly saline soils. Groundwater is located at a depth of 5-8 m. The association of white wormwood with caragana involves 17 species. In the first tier with an abundance of 3 and an average height of 42 cm, the dominant of the association is located - *Salsola dendroides* Pall. In the second tier, with an abundance of 2, and an average height of 35 cm, the subedificator of the association is *Artemisia lerchiana* Weber. In the third tier - with an abundance of 1-2, and an average height of 12-17 cm, it is located from cereals - *Poa bulbosa* L., *Aegilors truncialis* L., *Phalaris minor* Retz., *Hordeum leporinum* Link, and from the motley grass with abundance 1 and an average height of 10-35 cm *Medicago minima* (L.) L., *Allium rubellum* M.Bieb, *Papaver phoeas* L., *Sisymbrium irio* L., *Erodium hoefftianum* C.A. Meyer, *Torilis nodosa* (L.) Gaertn., *Senecio vernalis* Waldst. &Kit. etc.

The association formed by caragana with annual saltworts (*trichohydrophytes*) is common on meadow soils with a saline surface and is represented by 13 species: the ratio between annuals (9) and perennials (4) exceeds two times. Groundwater is located at a depth of 2.5-3.5 m. The total projective cover is 60%.

Formation class – *Salsola* L. Formations with saltworts occupy a wide space in the desert vegetation type of the studied territory. The development of vegetation depends on annual meteorological conditions, primarily on the amount of precipitation in annual saltwort deserts. Then the vegetation will be sparse, and in the case of heavy precipitation, there will be an abundance of vegetation if there is drought during the growing season. Annual saltwort deserts are represented by 4 formations and 10 associations in the study area. Of the formations common in annual saltwort deserts, the following are dominant: *Climacoptera crassa* (Bieb.) Batsch, *Petrosimonia brachiata* (Pall.) Bunge, *Salicornia europaea* L., *Suaeda confusa* L.

Suaedetum formation is most common in annual saltwort deserts of the studied territory. Mainly form thickets in saline solonchaks, sandy, saline soils.

The dominant of the formation is *Suaeda confusa* İljin. Formation is represented by two associations: a) *Suaeda confusoso – Petrosimonia brachiatosum*; b) *Suaeda confusosum* (fig. 8).

The *Petrosimonium ramosa-Sweda tangled* association includes 16 species: 12 species (75%) are annual, 4 species (25%) are perennial. The total protective cover is 20-35%.

The first tier is occupied by *Halostachys belangeriana* (Moq.) Botsch. with an abundance of 2 and an average height of 110 cm (Fig. 9). The second tier with an abundance of 1 and an average height of 27 cm is occupied by *Suaeda microrhiylla* Pall. This tier also includes the dominant *Suaeda confusa* Iljin. with an abundance of 4 and an average height of 20 cm; from cereals - with an abundance of 1 and an average height of 20-30 cm *Aegilops triuncialis* L., *Eremopyrum orientale* (L.) Jaub.&Spach., etc., and from motley grass with an abundance of 1 and an average height of 12-35 cm - *Petrosimonia brachiata* (Pall.) Bunge, *Torilis nodosa* (L.) Gaertn, *Salicornia europaea* L., *Limonium meyeri* (Boiss.) Kuntze, *Climacoptera crassa* (Bieb.) Batsch, *Cerastium perfoliatum* L.), etc.

Fig. 8. *Suaeda confusa* L.

Fig. 9. *Halostachys belangeriana* (Moq.) Botsch.

One of the main formations in small shrub saltworts is the *Halostachisetum* formation. This formation is formed by the Caspian saltwort, which is a tall halophyte, common in wet solonchaks and saline soils. The Caspian saltwort forms a wide strip on the road in the direction of the Kurdamir district in the studied area. The edificatory of the formation is *Halostachys belangeriana* (Moq.) Botsch. Formation is represented in the studied area by 3 associations: *Halostachis belangerianoso – Tamarix ramosissimosum*; *Halostachis belangerianoso – Erhemerotosum*; *Halostachis belangerianosum*.

The ephemeral-saltwort association includes about 21 species: shrubs are represented by 2 species, subshrubs by 1 species, bushes by 1 species, cereals by 6 species, and motley grass by 11 species. Of these, 16 species are annual and biennial, and 5 species are perennial. The projective cover is 30-40%.

The first tier is occupied by the dominant *Halostachys belangeriana* (Moq.) Botsch. with an abundance of 3 and an average height of 120 cm. This tier also includes *Tamarix ramosissima* Ledeb. The second tier includes *Suaeda microphylla* (Pall.) C.A.Mey. with an abundance of 1 and an average height of 30 cm. The third tier includes *Aeluropus littoralis* (Gouan) Parl, *Eremopyrum triticum* (Gaertn.) Nevski, *Lolium rigidum* Gaud., *Bromus japonicas* Thumb, etc. with an abundance of 1 and an average height of 10-30 cm, and a variety of motley grass: *Salicornia europaea* L., *Climacoptera crassa* (Bieb.) Batsch, *Petrosimonia brachiata* (Pall.) Bunge, *Atriplex sagittata* L., *Suaeda confusa* L., *Sisymbrium loeselii* L., *Salsola soda* L., *Gamanthus pilosus* (Pall.) Bunge, etc.

CONCLUSIONS

1. The main species that form associations and formations of semi-desert and desert vegetation in the flat part of the Shirvan zone of Azerbaijan were identified as a result of the analysis of botanical groups.
2. The desert plant types of the Shirvan territory are zonal in nature and the desert type is formed by 2 formational classes, 6 formations and 19 associations, semi-desert type – 3 formational classes, 3 formations and 9 associations have been revealed in results of the research.
3. The obtained data indicate the problems of desertification in the studied region, which is inevitably associated with climate change. Considering that the Shirvan region is the food base of the Republic it is necessary to increase the vegetation cover and promote the rational use of biotic resources in areas subject to or affected by desertification and drought, in particular, on the basis of such measures as afforestation, agro- and community forestry, as well as programs for the conservation of vegetation, and the implementation of phytomeliorative work.

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