Features of the formation of vegetation on alkaline soils of anthropogenic origin

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Abstract. As a result of the environmental impact, natural landscapes are substantially transformed into derivative anthropogenic systems. An example of this process is the anthropogenic extrazonal alkali soils (Tobolsk district, Tyumen region, Russia) at the places where salt water exits from wells drilled during geological exploration works. The vegetation of such alkali soils was studied in two areas of the Tobolsk district: near the villages of Kachipovo and Bekerevka. The species composition of such communities depends on the location relative to the well, and the time of exposure to ground and flood waters. The maturity of the associations of alkali soils is characterized by the halophyte saturation and by the peculiarity of the age composition of their populations. As the impact of salt water decreases, indigenous zonal vegetation is restored at the site of alkali soils. Artificial salinization of the soil near the wells contributed to the accumulation of halophytes of both relict and anthropogenic origin. To compare vegetation on alkaline soils of anthropogenic origin, a site with natural vegetation was studied as a control.

1. Introduction

Solonetzes are formed as a result of the solonetnic process of soil formation, which is based on peptization of colloids, an increase in the dispersion of the mineral mass and solubility of organic matter under the action of metabolic sodium and soda; as well as due to leaching of peptized colloids from the upper horizons and their coagulation in the illuvial horizon. The source of sodium and soda are water-soluble salts of sodium, which accumulate in arid climates in closed drainage territories [1].

The vegetation of salt marshes is usually represented by a small group of constantly occurring species of succulent (water-storage) halophytes. Specific solonetnic communities represent it. Plants which grow on solonetzes and solonetnic soils are called solonetnic. Due to the peculiarities of the water-salt regime and the physical properties of solonetnic soils (water resistance, significant density, alkaline reaction and salinity of the lower layers), these plants are able to withstand significant desiccation and compaction of the root layer and its enrichment with water-soluble salts in wet periods of the year. As a rule, solonetz plants are characterized by a developed surface root system. Some plants of saline soils usually form large thickets and can be used economically. Others, found in small quantities, can be propagated and introduced into the culture. Natural salty landscapes provide significant ecosystem services to humans: salt production (salt-farming) and plant species (salty plant cropping) [2-4].
Distinguished by their salinity, alkali soils are characterized by the growth of facultative or obligate halophytes. This study explores the species composition of plants and the associations formed from them in the vicinity of a mineral well 2 km south of the village of Bekerevka, Tobolsk district, Tyumen region, Russia \((N58^020^\prime06^\prime E68^017^\prime37^\prime4\), and the village of Kachipovo, Tobolsk district, Tyumen region, Russia \((N57^020^\prime55^\prime E68^017^\prime08^\prime4\). The unique source of hot water in this area was discovered by geologists as far back as in the 1970s.

A mineral water source was discovered by chance about 70 years ago during exploration for oil and well drilling and the well was mothballed in 2012. The well can produce mineral water containing potassium, sodium, bromine and iodine.

During the existence of the well, salt water flowed down the slope to Yerek River (the old riverbed of Irtysh). The runoff is gutter-shaped and not deep (up to 0.5 m below the adjacent meadow areas), but rather wide (from 30 m at the well to 100 m at the Yerek River).

Due to discharge of salt water, soils were saturated with salts, which later resulted in formation of associations of alkali soils. The lower part of the runoff was flooded with flood waters, which led to partial desalinization of soils and a change in the species composition of the associations. This explains zonality (stripe pattern) of alkali vegetation along the gutter. Water flow from the well near the village of Kachipovo occurred along the bottom of a forest ravine towards the Tobol River. The formation of alkali vegetation at this location was significantly influenced by melt and rain waters from the territories surrounding the alkali soil area, as well as proximity to the surface of groundwater.

The aim of this work is to compare the species composition of plants in associations on alkali soils of anthropogenic origin to elucidate the features of the formation of such associations, their relationship with the surrounding native vegetation and its restoration on similar alkali soils.

2. Materials and methods
The vegetation was described during the growing seasons according to the methodological methods and approaches adopted in phytocenology and widely used in geobotanical studies [5].

Counting the number of individuals on the studied alkaline soils of anthropogenic origin was carried out by the method of test plots \(1\text{m}^2\) in triplicate. The degree of salinity and leaching was determined indirectly from the abundance of the indicator species Tripolium vulgare Ness. The number of individuals of this species near the well was taken as control. The plots were located at a distance of 5 meters from each other along the center line of the saline water flow. For comparison, in the area of natural vegetation of the floodplain of the Irtysh River, 5 test plots of 1 m² were laid. The site was located at a distance of 300 meters from anthropogenic salt licks.

To determine the abundance, the Drude scale was used – a system of point-based ocular estimate grades used for assessment of the abundance of the species: soc (socialis) – plants foniruyut; cop\(_3\) (from copiosa – copious) – very copious; cop\(_2\) – copious; cop\(_1\) – fairly copious; sp (sparsae) – absentmindedly; sol (solitaries) – thin, scattered; un (unicum) – occurs singly [6].

The studies were carried out in July-August 2019. The area of saline areas near the village of Bekerevka is \(40 \times 200 \text{ meters}\), near the village of Kachipovo \(20 \times 100 \text{ meters}\).

The nature of plant associations on alkali soils near the village of Bekerevka was distinguished by a set of indicator species. Salicornia europaea L., Tripolium vulgare Ness., Spergularia diandra (Guss.) Heldr. According to the ratio of facultative and obligate halophytes, four stripes are allocated along the saline water gutter over the slope towards the old riverbed, oriented latitudinally with respect to the flow direction; they can be arbitrarily marked with letters (A, B, C, D) with the characteristics described below. The most salinized soils in stripe A contributed to the growth of obligate halophytes, while in stripe B the contribution of obligate halophytes decreased and indigenous species played a significant role. In stripe C, facultative halophytes grew from indigenous species in the composition of associations. In stripe D, pioneer ephemeralphyte communities were formed over the slope of the bank towards the old riverbed.
3. Results and discussion

Stripe A (radially around the well, about 10-15 m away). Here, indicators of *Tripolium vulgare* Ness. (60-80 plants/m²). *Juncus compressus* L. (200 shoots/m²) are the most abundant. Their renewal is maximum; salt crusts form on the surface of the soil. Only here *Salicornia europaea* L. massively grows. In this stripe, the soils are most salinized, therefore *Tripolium vulgare* – *Juncum compressae*, *Puccinellio hauptiani* – *Tripolium vulgare compressae* associations are formed here.

*Tripolium vulgare* – *Juncum compressae* association. The total projective coverage is about 85%. The community is three-layered. The dominants are *Salicornia europaea* L. and *Juncus compressus* L. The first layer is formed by *Tripolium vulgare* Ness. Two species grow in the second layer, of which *Juncus compressus* L. grows massively (cop1, coverage rate of 20%), *Melilotus albus* L. is found singly. The third layer is formed by the dominant *Salicornia europaea* L. and background forming *Spergularia diandra* (Guss.) Heldr. et Sart.

*Puccinellio hauptiani* – *Tripolium vulgare* association. The community is dominated by *Puccinellia distans* (Jacq.) Parl. and *Tripolium vulgare Ness*. *Juncus compressus* L. and *Tripolium vulgare* Ness grow in the first layer.

Stripe B is about 10×30 m. Compared to stripe A, the abundance of *Tripolium vulgare* Ness. drops to 40-50 plants per 1 m², the contribution of *Juncus compressus* L. becomes less significant (100-120 shoots per 1 m²). In this stripe, the contribution of herbs and legumes in the associations increases. Halophytes (*Puccinellia hauptiana* Krecz., *Spergularia salina* J. et C. Presl.) are less abundant compared to stripe A. With regard to cereals, the increasing contribution of *Agrostis gigantea* Roth., *Agrostis vinealis* Schreber, and occasionally *Agrostis stolonifera* L., is observed. The following associations are described here: *Elyrtigio repensi* – *Tripolium vulgare*, *Elyrtigio repensi* – *Ptarmicum salicifoliae*. Descriptions of these associations are given below.

*Elyrtigio repensi* – *Tripolium vulgare*. The total projective coverage is 90%, which to some extent reflects a decrease in soil salinity compared to Stripe A. Observations of the grass cover of the studied artificial alkali soil patch showed that with an increase in soil salinity the grass cover is thinning. The phytocenotic positions of individual species also change. In this vein the abundance of wheatgrass *Elytrigia repens* (L.) Nevski, *Odonites serotina* (Lam.) Dumort., rarely - *Leontodon autumnalis* L. and *Melilotus officinalis* L.

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*Elyrtigio repensi* – *Ptarmicum salicifoliae*. The total projective coverage is 90%, the community is three-layered. Its distinctive feature is the abundance of legumes, some of which significantly exceed in size specimens found in typical conditions (*Trifolium pratense* 0.90 m). This association was located on the periphery of strip B in the zone of transition to non-salinized sections of the meadow. The dominant (*Tripolium vulgare* Ness.Soc) represents the second layer, and the subdominant *Ptarmica salicifolia* forms the first layer, in which *Elytrigia repens* L. Nevski also grows. The decrease in soil salinity in the range of this association is confirmed by the absence of typical halophytes.

Stripe C (40×60 m) belongs to the grain and grass type with an abundance of *Agrostis gigantea*, *A. vinalis* and *Elytrigia repens*. In comparison with the other stripes, this one is the largest in area. Within its limits, species typical for moistened alkali soils (*Atriplex prostrata, A. laevis*) were found. This stripe is characterized by the *Agrostio stoloniferi* - *Tripolium vulgare* association.

*Agrostio stoloniferi* - *Tripolium vulgare*. The association is three-layered, dominated by the bentgrass *Agrostis albida* and *Tripolium vulgare*. A distinctive feature of *Elytrigia repens* within the studied areas of growth is bushiness (close-growing specimens of 3-4 generative and rather high shoots up to 1.10 m in height). Dominators are *Tripolium vulgare* Ness (cop1) and *Agrostis albida* Trin. (soc). The total projective coverage is 100%. Dominance of *Agrostis albida* Trin.
and other types of cereals makes it difficult for herbs to renew, therefore, their species are found singly or in a small number of plants. The alkalization conditions in this stripe are peculiar. On the one hand, halophyte species typical of stripe A are absent here or are represented by single specimens (*Juncus compressus*). But at the same time halophytes are present (*Atriplex prostrata* Boucher ex DC., *Atriplex laevis* C.A. Meyer, *Rumex stenophyllus* Ledeb.) that are not found in the rest of the territory of this alkali soil patch of anthropogenic origin.

In the right sector of stripe C, mass shrinkage of shrubs (*Salix cinerea*, *S. rosmarinifolia*) was observed, where the tall grass community of Phalaroidio arundinaci - *Tripolium vulgare* was formed. The following is a description of this association.

A distinctive feature of this association is the growth of large cereals (*Phalaroides arundinacea* (L.) Rausch., *Elytrigia repens* (L.) Nevski, *Agrostis gigantea* Roth.) and tall grasses (*Angelica sylvestris* L., *Sium latifolium* L., *Rumex pseudonatranatus* (Borb.) Borb. ex Murb.). In this community, soil humidity is increased (the growth of *Galium palustre* L.), so the soils are washed deeper, which is favorable for the growth of tall grasses. Although the presence of salts in the soil contributes to the high abundance of *Tripolium vulgare* Ness.

Stripe D is characterized by vegetation with a sharp predominance of background-forming annual plants *Chenopodium glaucum* L. and *Chenopodium rubrum* L. and a group distribution of perennials. Saltwater runoff ends on the slope of the Erek River bank, where a strip of ephemeroophytes with certain types of hemicyryptophytes is formed. The soils here feature a system of cracks. This area is flooded for prolonged periods, so the vegetation here is represented either by annuals (*Ranunculus sceleratus* L., *Chenopodium rubrum*, *Chenopodium glaucum*, *Spergularia marina* (L.) Griseb.) or perennials with creeping or vegetative shoots (*Agrostis stolonifera*, *Alopecurus aequalis* Sobol., *Ranunculus reptans* L., *Ranunculus sceleratus* L., etc.). However, in general the formation of vegetation on the bank slope is affected by salted water flowing from the well. This is confirmed by the growth of an indicator species, halophyte *Tripolium vulgare*, in all of the associations. The ratio between annuals and perennials depends on the proximity of a particular association to the slope of the Erek River bank. The following associations were found here: *Chenopodio glauci* - *Chenopodium rubrae*, *Plantagio intermedi* – *Alismum plantago – aquaticae*, *Chenopodio rubrae* – *Spergularium marini*.

Geobotanical features of the *Chenopodio glauci* - *Chenopodium rubrae* association. The total projective coverage is over 50%. The plants are distributed by the diffuse (annuals) or group (perennials) types. Of note is that *Eleocharis mamillata* Lindb. fil. – a rare species in the flora of Western Siberia – grows here. Perennials are oppressed in this community - this is indicated by their size. The plants growing farther away from water along the slope become larger. A distinctive feature of these associations along the almost exposed slope of the bank is the abundance of *Plantago intermedia* DC. With its participation, the association of *Plantagio intermedi* - *Alismum plantago – aquaticae* was formed.

*Plantagio intermedia* - *Alismum plantago – aquaticae*. The community occupies a transition stripe from the bentgrass meadow to the butt-goosefoot community of the old riverbed slope. In some places, a salt crust is visible. The plants are distributed mainly in clusters. The total projective coverage is about 70%, the association is three-layered. An association of *Chenopodigio rubresa* - *Spergularium maritae* was found along the same slope of the bank.

The *Chenopodio rubri* - *Spergularium marini* association corresponds to the pioneer stage of community formation, as evidenced by the small number of perennial species with diffuse distribution of plants, the lack of closeness and predominance of annuals. The layering is weak. The total projective coverage is about 60%. In the soil cover, fractured clay soils are abundant. Of the goosefoots, *Chenopodium rubrum* is notable for its significant abundance. During our observation, *Chenopodium rubrum* and *Chenopodium glaucum* were at the budding stage and in the beginning of flowering. The association is notable for the growth of an aqueous form of *Alopecurus aequalis*.

The associations on alkali soils of anthropogenic origin described above are formed on the basis of the vegetation of the Irtysch floodplain meadow in the basin of its old riverbed Erek. For comparison...
purposes, a forb-grass association of the floodplain meadow located near the formed alkali soil patch was described.

The total projective coverage of the Galigio physocarpi - Allium angulosae association is 100%. The four-layer community is dominated by *Galium physocarpum* L. Meadow associations with the dominant *Allium angulosum* are rare in the Irtysh floodplain. Several aspects highlight in such associations during the growing season, two of which, white (*Galium physocarpum*) and lilac (*Allium angulosum*), are determined by the mass flowering of the dominants of this association. The predominate representative of herbs is Asteraceae (*Hieracium umbellatum* L. and others). Legumes are represented by *Trifolium pratense* and others. On alkali soils, the number of legume species decreases, although new synanthropic species (*Melilotus albus*) also appear. In the first layer, *Sanguisorba officinalis* L. and *Thalictrum simplex* L. are found. In the second layer, cereals are widely represented: *Poa pratensis* L., *Festuca pratensis* Huds., *Deschampsia cespitosa* (L.) P. Beauv. The second layer determines the phytoclimate of the meadow association (humidity, lighting, gas composition features).

In the third layer there are numerous species of herbs: *Gentiana pneumonanthe* L., *Ramunculus polyanthemus* L., etc. The growth of rather rare species for the Siberian flora in the third layer of the association is notable: *Allium angulosum* L., *Iris sibirica* L. These species perished on alkali soils due to changes in the pH of the soil solution that does not meet their environmental requirements. The association of *Galigio rubioidi - Allium angulosae* accounts for 27 species per 400 m². If we compare the species composition of the *Galigio rubioidi - Allium angulosae* association with a set of species on alkali soils of anthropogenic origin, we can note the following:

- a decrease in the total number of species from 27 (*Galigio rubioidese - Allium angulosae* association) to 10-19 in associations on alkali soils of anthropogenic origin. At the same time, halophyte species settle on alkali soils while halophobic species disappear;
- some species of Poaceae change their morphological features adapting to the soil, for example, *Elytrigia repens* becomes densely bushy (3-5 generative shoots are noted in the bushes), tall (shoots reach up to 1.2 m in height), and long-spiked (spikelets up to 15 cm);
- change in the activity of individual species. This is applicable primarily to species of the genus *Agrostis*. In the third stripe D, bentgrass meadows with a set of facultative halophytes (*Atriplex prostrata, Atriplex laevis*) are even formed on the alkali soil patch;
- semi-parasites such as *Melampyrum cristatum* L., *Rhinanthus serotinus* Oborny and others are highly involved in the association of *Galigio rubioidese - Allium angulosae*. On alkali soils they are represented by a small number of plants of *Odontites serotina*, a facultative semi-parasitic halophyte.

In the vicinity of the village of Kachipovo, alkali soils of anthropogenic origin are also formed near a similar preserved well. But unlike the alkali soils of the village of Bekerevka, they are formed along the bottom of a forest ravine and are affected by the close groundwater stand. Therefore, alkali soils with signs of bogging are noted here. The following associations have been described: *Elytrigio repensi – Tripolium vulgarae*, *Tripolium vulgare – Phragmitum altissimae*, *Phragmitio altissimi* – *Puccinellium hauptianae*.

The species composition of the *Elytrigio repensi - Tripolium vulgarae* association is an example of the restoration of native vegetation in place of an artificially formed alkali soil patch. The total projective coverage of the grass layer is 90%. There are small areas with salt crust, devoid of vegetation. The association is three-layered. The dominants are *Elytrigia repens* and *Tripolium vulgare*. Halophyte species (*Tripolium vulgare, Puccinelli and hauptiana*) with significant abundance (cop1- cop3) reflect the preserved salinity of soils, but within their transition to the background gray forest soils, the abundance of these halophytes decreases. Poaceae and Asteraceae lead in the number of species in this community, as their species have a fibrous root system that forms in the upper, less salinized horizons.

The growth of the semi-parasite *Rhinanthus serotinus* also indicates the degradation of the alkaline meadow community. With close groundwater stand in associations within the alkali soil patch near the
village of Kachipovo, the role of *Phragmites altissimus* (Benth.) Mabille, an inductor of closely spaced groundwater, increases.

The transitional community of *Tripolium vulgari - Phragmitum altissimae* (*Juncceum compressum*) with the contribution of (*Tripolium vulgare*). The total projective coverage of *Tripolium vulgareae* - *Phragmitum altissimae* is 100%. The association is four-layered. The dominants are *Phragmitus altissimus* (Benth.) Mabille (cop 1) and *Tripolium vulgare* (cop 1). The position of *Tripoli vulgari - Phragmitum altissimae* associations within the alkali soil patch in the vicinity of the village of Kachipovo is two-fold. Firstly, the association represents the next stage of vegetation restoration on alkali soils. This was manifested both in strengthening the role of legumes and in reducing the abundance of halophytes. Secondly, this association is a stage of restoration of vegetation of not dry, but wet alkali soils. This is indicated by the growth of *Phragmitus altissimus* and *Juncus compressus* in its composition. The latter species is the dominant of alkali soil patch associations in the vicinity of the village of Bekerevka. *Phragmitus altissimus* also proved resistant to salinization during the formation of wet alkali soils. This was especially evident in the association of *Phragmitio altissimii - Puccinellium hauptianae* with significant contribution of *Tripolium vulgare*.

The association of *Phragmitio altissimii - Puccinellium hauptianae* is represented by thickets and the association is characterized by the maximum height in comparison with plants of the common tripolium from other associations. This is due to a combination of optimal conditions for the species on wet alkali soils, as well as the influence of *Phragmitus altissimus*, which causes increased growth of *Tripolium vulgare*. The association of *Phragmitio altissimii - Puccinellium hauptianae* shows signs of menopause, which is associated with its long existence in this place.

The indicator of alkali communities *Tripolium vulgare*, which is included in all associations within the anthropogenically formed ecosystem of alkali soils, reflects to a certain extent the degree of salinization of soils through the characteristics of the age composition. *Tripolium vulgare* is a triennial. Shoots appear in the first year. In the second year, vegetative plants develop. In the third year of life, plants bloom and seed. Anemochorous seeding in combination with high seed productivity allows *Tripolium vulgare* to intensively spread and settle in disturbed growth sites. The age composition of *Tripolium vulgare* in associations on alkali soils of anthropogenic origin near the village of Bekerevka was analyzed. The calculations were carried out in triplicate on plots of 1 m². The table contains standard errors. The studies were carried out from one research center. The obtained data in Table 1 are the average values of the sum at the site of each association in triplicate (table 1).

Vegetative plants of *Tripolium vulgare* differ in the number of leaves formed on the caudex (table 1): from one to four. Univalent plants usually do not bloom in the third year of their life. Bifacial plants act as an indicator of the high vitality of the population. A high value of this indicator was noted in populations of the associations of *Tripolio vulgari - Junccum compressae*. Many researchers believe that the formation of saline soils is associated with the accumulation of salts in groundwater and rocks and with conditions conducive to their accumulation in soils.

Synanthropization of urban vegetation is accompanied by a change in the chemical composition of soils, including salinization. This facilitates the penetration of alien species, which was noted in this study [7-9]. Alkaline soils are soils containing a large amount of water-soluble salts from the surface downwards and in the profile. The accumulation of salts in soils is the essence of the salinization process. Plant species inhabiting saline soils migrate as a result of climate change and form new plant associations [10-12]. Perhaps the formation of the associations we are studying is partly of this type. Plants are able to withstand significant desiccation and compaction of the root layer and its periodic enrichment with water-soluble salts during the wet periods of the year. Alkali soil plants combine the signs of xerophytes and halophytes [13-15]. In our studies, a comparison of the species composition in the studied associations showed that facultative halophytes (*Atriplex prostrata* L. and others) prevail over obligate ones (*Salicornia europeaea* L. and others).
Table 1. Specific features of the age composition of *Tripolium vulgare* in associations of the alkaline meadow near the well located near the village of Bekerevka (Tobolsk district, Tyumen region, Russia).

| Associations                      | H, cm | Shoots | with 1 leaf | with 2 leaves | with 3 leaves | with 4 leaves | Blooms |
|-----------------------------------|-------|--------|-------------|---------------|---------------|---------------|--------|
| *Tripolio vulgari - Junceum*      | 40±2.2| 22     | 3           | 12            | 8             | 2             | 100    |
| *compressae* Puccinellio*         |       |        |             |               |               |               |        |
| *hauptini-*                        | 52±3.0| 16     | 4           | 9             | 7             | 1             | 52     |
| *Tripolium vulgarae*              |       |        |             |               |               |               |        |
| *Elyrtigio repensi-*              | 60±3.5| 12     | 6           | 8             | 6             | 2             | 49     |
| *Tripolium vulgarae*              |       |        |             |               |               |               |        |
| *Elyrtigio repensi-*              | 64±4.2| 20     | 9           | 10            | 5             | 3             | 60     |
| *Ptarmicum salicifoliae*          |       |        |             |               |               |               |        |
| *Agrostio stoloniferi-*           | 30±1.8| 9      | 1           | 7             | 1             | 5             | 30     |
| *Tripolium vulgarae*              |       |        |             |               |               |               |        |

In these studies, associations differ in the activity of dominants. But just such a combination is favorable for the germination of seeds of certain species. In the association of *Elytrigio repensi - Tripolium vulgarae*, the number of vegetative plants of *Tripolium vulgare* is very low in comparison with other associations. This is due to the influence of *Elytrigia repens*. Plants of this species on alkali soils near the village of Bekerevka reach 1.2 m in height; the abundance of (*Elytrigia repens - soc*) counteracts the intrusion of *Tripolium vulgare* into this population.

The number of germinated seeds of *Tripolium vulgare* in the ecosystem ranges from 22 (the association of *Agrostio stoloniferi - Tripolium vulgarae*) to 9 (the association of *Agrostio stoloniferi - Tripolium vulgare*). Such significant differences in the number of seedlings are associated with the abundance of related species. The presence of dead grass and the high abundance of *Agrostis stolonifera* in the association of *Agrostio stoloniferi - Tripolium vulgareae* makes it difficult for *Tripolium vulgare* seedlings to reach the soil, which significantly reduces the seed germination rate. The abundance and parameters of generative plants of *Tripolium vulgare* vary in populations depending on the association of their growth. Generative plants of *Tripolium vulgare* vary greatly in height - from 0.4 to 1.0 m. Observations show that the height of plants is more dependent on the abundance and height of related species. In this vein, in the association of *Phragmitio altissimi - Tripolium vulgareae* with the dominant (*Phragmitus altissimus*) height of up to 2.50 m, the height of *Tripolium vulgare* reaches up to 1.1 m.

4. Conclusion
The communities on the alkali soil patch arose on the basis of the vegetation of the floodplain meadow when its dominants were replaced by halophytes, while some of the native species more resistant to salinity were retained. The determining environmental factors are the level of salinization of the soil, the nature of its washing by flood waters, and the depth of groundwater occurrence.

There are two possible options of population of the ecotope exposed to salt water as an artificial drift of species via the railway passing 1.5 km south of the well or from the side of the village. Halophyte seeds could be introduced by the Irtysh river. The second option of the origin of associations of alkali soil plants is that they are indigenous to this place. In this case, the question of relict sites of halophyte growth in the meadow associations of Irtysh (Pleistocene heritage) arises. The
influence of the Pleistocene events on the flora of the vicinity of Tobolsk resulted in steppe groups along the root bank of Irtysh (near the city of Tobolsk) and the growth of a number of salsuginous species (Triglochin maritima and others). The restoration of disturbed natural plant communities during the emergence of alkaline soils of anthropogenic origin and their leaching occurs mainly due to species of the Poaceae family, often with halophytic, facultative directions.

References

[1] Montoroi J P 2020 Soil salinization and management of salty soils: degradation and rehabilitation. Soils as a Key Component of the Critical Zone 5. (Electronic Material vol5) ed C Valentin (USA: While Online Library) chapter 5 pp 97–126 https:// doi: 10.1002/9781119438298.ch5

[2] Zhu Y, et al. 2020 Conversion of coastal marshes to croplands decreases organic carbon but increases inorganic carbon in saline soils. Land Degradation and Development 31 9 https://doi:10.1002/ldr.3538

[3] Clapp C E, Hayes M H B, Simpson A J and Kingery W L 2018 Chemistry of soil organic matter. Chemical Processes in Soils ed AM Tabatabai, et al. (Madison, WI) pp 1–150 doi: 10.2136/sssabookser8.1

[4] Hodson M E and Donner E 2013 Managing adverse soil chemical environments. Soil Conditions and Plant Growth ed P J Gregory and S Nortclif (New Jersey: Blackwell Publishing Ltd) chapter 5 pp195 –237 doi: 10.1002/9781118337295.ch7

[5] Punyasena S W and Smith S Y 2014 Bioinformatic and biometric methods in plant morphology. Appl. Plant Sci. 2 1400071 doi:10.3732/apps.1400071

[6] Strong W L 2002 Assessing species abundance unevenness within and between plant communities. Community Ecol. 3 2 https://doi:10.1556/comec.3.2002.2.9

[7] Abramova L M 2012 Expansion of invasive alien plant species in the republic of Bashkortostan, the Southern Urals: analysis of causes and ecological consequences. Russ. J. Ecol+ 43(5) 352 DOI: 10.1134/S1067413612050037

[8] Uchiya P, Escaray F J, Bilenca D, Pieckenstain F, Ruiz O A and Menéndez A B 2016 Salt effects on functional traits in model and in economically important Lotus species. Plant Biol. 18 703 doi:10.1111/plb.12455

[9] Tabacchi E, González E, Corenblit D, Garófano-Gómez V, Planity-Tabacchi A M and Steiger J 2019 Species composition and plant traits: Characterization of the biogeomorphological succession within contrasting river corridors. River Res. Appl. 1 13 https://doi.org/10.1002/rra.3511

[10] Flanagan N E, Richardson C J and Ho M 2015 Connecting differential responses of native and invasive riparian plants to climate change and environmental alteration. Ecological Applications. 25 753 https://doi:10.1890/14-0767.1

[11] Elias P Jr, Sopotlieva D, Dite D, Hajkova P, Apostolova I, Senko D, Meleckova Z and Hajek, M 2013 Vegetation diversity of salt-rich grasslands in Southeast Europe. Applied Vegetation Science. 16(3) 521 https:// doi: 10.1111 / avsc.12017

[12] Gibson R K, Bradstock R A, Penman T, Keith D A and Driscoll D A 2015 Climatic, vegetation and edaphic influences on the probability of fire across mediterranean woodlands of south-eastern Australia. J. Biogeogr. 42 9 https://doi:10.1111/jbi.12547

[13] Toth T 2010 Medium-term vegetation dynamics and their association with edaphic conditions in two Hungarian saline grassland communities. Grassland Science. 56 1 https://doi:10.1111/j.1744-697X.2009.00167.x

[14] Ivushkin K, Bartholomeus H, Bregt A K and Pulatov A 2017 Satellite thermography for soil salinity assessment of cropped areas in Uzbekistan. Land Degradation and Development. 28 870 https://doi: 10.1002/ldr.2670.

[15] Schofield R, Thomas D S G and Kirkby M J 2001 Causal processes of soil salinization in Tunisia, Spain and Hungary. Land Degradation and Development. 12(2) 163 https://doi:10.1002/ldr.446