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Investigation of the Vegetation on Saline-alkaline Soils and Marshes of Iğdir Plain in Turkey

A. Istanbulluoglu

Trakya University, Tekirdag Agricultural Faculty,
Agricultural Construction and Irrigation Department, 59030 Tekirdag, Turkey

Abstract: This study involves in the investigation of halophytic vegetation in Iğdir Plain which comprises of partly summer drying and partly prominent saline and alkaline marshes, located near Ararat Mountain in the Eastern Turkey. Six associations and three sub-associations were identified in the plain. *Arthrocnemum glaucum*, *Halimiono-Arthrocnemum glaucum* and *Halocnemo-Salsolietum macrae* associations were described in the area where the soil surface was covered by a white salt crust accompanying with extremely sodium, boron and lime contents. *Junco-Puccinellietum distans* association was widespread in the waterlogged marshes area of the plain while *Panderino-Tamericetum parviflorae* association prevailed on the soils containing small amount of salt and lime, and having no alkalinity and acidity problem (i.e. neutral in pH). *Kochio-Schismetum arabicus* was seen in the soil showing the characteristics of no salinity and low alkalinity problem and containing small amount of lime. This area was the transition zone between the wind erosion and highly saline and alkaline soils. All these associations, except *Arthrocnemum glaucum*, were described in this study for the first time. *Junco-Puccinellietum distans* association was included in *Puccinellio-Salicornion europae* alliance of *Salsola-Aeluropetalia litoralli* order. The other associations were grouped under *Alhagio-Suaedion microphyllae* alliance that was identified in this study for the first time.

Key words: Ararat mountain, Iğdir plain, plant association, saline and alkaline soils, marshes, Turkey

INTRODUCTION

One of the major practices to promote agricultural production is the introduction of irrigation. But introduction of irrigation to arid/semiarid regions without taking precautions may lead serious waterlogging, salinity and alkalinity problem. Saline and alkaline soils are generally accompanied with poor drainage conditions. The magnitude of these problematic soils, alkaline and saline, in Turkey and around the world, which may be converted to very productive lands when they improved, occupies significant area. Some 1.5 million ha of the total of 12.5 million ha irrigated land in Turkey has irrigation induced salinity and alkalinity problem^[1].

Studies on the diagnose and improvement of saline and alkaline soils started towards the end of the 19th century and considerable progresses have been made parallel to the development in science and technology. The area should thoroughly be investigated and the existing problem must be identified carefully prior to the improvement of saline and alkaline soils.

In the investigations of saline and alkaline soils, description of the natural vegetation besides determination of salt, sodium, boron and pH status of the

soil is vital because natural plant associations are the typical indicator of environmental conditions^[2].

The objective of this study is to investigate phytosociology of Iğdir Plain, which has great agricultural potential but impeded due to the alkalinity and salinity problem, up to 36% of its total area, to promote the improvement process maintained by the World Bank.

MATERIALS AND METHODS

Iğdir Plain is located in the Eastern Turkey between 39°38' and 40°03' North latitude and between 44°49' and 45°31' East longitude and covers 680 km² area. The altitude of the plain ranges from 795 to 910 m. The plain, which is placed between the Great (5137 m) and the Small (3897) Ararat Mountain and the Aras River, is divided into two parts near Tasburun village by the lava from Ararat Mountain. The part in the west of Tasburun village is called Western Iğdir Plain whereas the one in the east of the village and lies up to the Iranian border is named as the Eastern Iğdir Plain (Fig. 1)^[3].

The plain shows different climatic characteristics from the Eastern Turkey due to the high mountains surrounding it. Summers are dry and hot while the winters



Fig. 1: Location of the experimental site

are moderate. Total annual precipitation is 233.7 mm, which is the driest micro-environment of Turkey and may be considered as arid area. Annual average temperature, relative humidity, wind speed, sunshine duration and evaporation are 13.0°C, 63%, 1.1 m s⁻¹, 6.28 h and 1094.9 mm, respectively^[4].

Iğdir Plain is covered by the basalt formed after the eruption of the lava from Mountain Ararat surrounding the south of the plain. The basalt is wrapped by the alluvial materials carried by the River Aras whose thickness reaches up to 150-200 m, varying with the location. The elevation of the bed of Aras River, flowing through the north of the plain and forming the border between Armenia and Turkey, is higher than the same part of the plain. Marshes covered with rushes and canes are seen in the south east of the plain due to the impermeable clayey surface^[5].

Predominantly practiced polycultural agriculture is limited by the soil and drainage problems rather than the climate. Alkalinity and salinity among many other soil problems occupy 36% of the plain^[6]. Natural vegetation adapted to this environment also exists. This vegetation is an index in the investigation of the characteristics and invasion of the problem area.

In order to investigate the phytosociology of alkaline and saline soils of Iğdir Plain, a herbarium was constructed through collecting vegetation samples with short time periods during three years. The sites, 16, 32, 60 and 100 m² in size, for vegetation description was also selected in respect to minimal area method as a representative area of a particular vegetation type and Braun-Blanquet method was used in the classification of plant communities and named according to the syntaxonomic rules^[7,8].

Profiles were opened in the sites where the plant communities were present predominantly and soil samples were collected from different depths in these profiles.

Besides texture analysis, pH, electrical conductivity (EC), lime (CaCO₃), total sodium (Na), exchangeable sodium percentage (ESP) and boron (B) analysis were done to identify the soil problem, organic matter, available phosphorous (P) and potassium (K) contents were also determined to investigate the productivity of the soil.

RESULTS AND DISCUSSION

Six associations were investigated in the plain. Soil properties of each association were described through carefully selected one or more soil profile representing selected sites in Table 1.

The distribution of the plant associations in the plain varied with the variation in the environmental conditions, from wind erosion area to saline and alkaline soils and to marches. The associations are classified as:

Arthrocnemetum glaucum Nova association: This association prevailed on the alkaline and saline soils on which white salt crust was seen in the area between Babacan-Hasanhan and Asagi Camurlu-Ramazankent villages whose altitude ranges from 850 to 860 m. The soil properties in the site where this association were predominantly seen was presented in Table 1. The values for EC, pH, ESP and B were extremely larger than the limits^[9] especially in the top 0-1 cm soil profile. Soil texture was classified as sandy-clay loam.

The association was characterised by the species *Arthrocnemum glaucum*, *Halocnemum strabillaceum*, which is the characteristic species of *Salsola-Aeluropetalia* order, placed in the ratio of 25%. *Alhagio-Suaedion microphyllae* alliance was represented by the species *Alhagio pseudelhagi*, *Halanthum roseum*, *Salsola crassa* and *Brachiaria eruciformis*. The association was the poorest one in the plain in respect to the density of species. The maximum number of species in the sample plots was five. The cover ratio of the association ranged from 25 to 80%. Annual species such as *Halanthum roseum* and *Salsola crassa* dies when salts concentrate and white salt crusts form on the soil surface in the summers. The remaining part of the soil surface other than covered by *Arthrocnemum* in scattered group becomes bare when the animals graze *Brachiaria eruciformis* and *Phragmites australis*. In general, because the thorn of *Arthrocnemum glaucum* gets hard after mid-summer and therefore cannot be grazed by the animals *Alhagio pseudelhagi* species participate.

Halimiono-Arthrocnemetum glaucum Nova association: This association was spread out in the area between the south and south west of Babacan village and Kiracbagi-

Table 1: Some chemical and physical properties of the soil at the experiment site

Plant associations	Soil deep (cm)	Saturated soil paste			Available (kg/ha)		Na (me/L)	ESP (%)	Boron (ppm)	Organic matter (%)	Texture (%)		
		pH	EC	Lime COCO ₂ (%)	P ₂ O ₅	K ₂ O					Sand	Silt	Clay
Arthrocnemum glaucum	0-1	9.3	30.0	3.1	70.4	-	27.7	98.9	10.0	0.84	49.3	28.7	22.0
	1-10	9.2	9.5	4.4	41.1	-	23.5	79.9	9.4	1.74	44.8	43.3	11.9
	10-30	9.2	10.8	2.7	31.8	-	21.8	60.7	8.6	1.62	31.4	56.5	12.1
	30-45	9.2	7.5	3.8	16.4	-	19.1	53.7	6.4	1.04	24.4	46.3	29.3
Halimione-Arthrocnemum glaucum	0-1	8.0	34.0	3.5	93.1	3084.0	70.4	71.1	13.2	2.79	25.5	49.3	25.2
	0-15	7.7	8.8	4.4	41.1	3049.3	72.0	60.8	17.8	3.20	21.3	69.7	9.0
	15-30	8.0	10.0	2.5	30.0	3884.1	58.3	55.5	16.2	2.61	16.3	53.9	29.8
	30-45	8.0	12.0	7.0	20.5	2189.2	46.2	50.4	12.0	1.68	10.4	63.0	26.6
	0-15	9.0	5.0	2.9	91.8	3590.3	33.0	48.1	15.0	1.68	21.8	67.5	10.7
	15-30	9.0	7.5	2.7	102.4	3990.4	22.6	34.2	10.6	2.09	22.0	71.2	6.8
Halocnemo-Salsolietum Macerae	0-1	7.6	25.0	4.3	84.6	3084.5	53.9	38.0	20.0	3.02	35.1	52.5	12.4
	0-15	7.7	8.0	3.0	72.7	4555.0	33.0	32.9	17.0	3.13	31.6	57.8	10.6
	15-30	7.8	8.0	6.2	16.4	2860.1	30.8	28.7	10.0	1.74	23.5	61.3	15.2
	30-45	7.8	8.0	3.3	64.4	2648.3	42.9	33.7	8.9	1.57	20.3	61.7	18.0
	0-1	7.6	20.0	2.2	103.4	6249.5	78.1	73.9	20.0	3.33	37.2	50.0	12.8
	0-15	7.8	12.5	3.6	83.0	3579.0	69.3	64.0	18.2	3.02	31.8	55.1	13.1
	15-30	8.0	8.1	4.3	3.0	3272.5	47.3	56.2	13.6	2.50	30.6	45.2	24.2
	30-45	8.2	11.5	4.8	12.3	3566.3	45.1	41.9	0.9	1.93	13.4	58.1	28.5
Kochio-Schismetum Arabicus	0-15	8.2	1.0	0.3	99.4	565.0	1.0	2.9	1.6	1.04	71.6	20.2	8.2
	15-30	8.1	0.5	0.2	104.1	459.0	1.2	3.8	0.3	2.26	75.6	18.2	6.2
	30-60	7.9	0.5	0.3	30.8	353.1	1.2	3.2	0.2	1.04	57.6	34.1	8.3
Panderino-Tamaricetum Parviflorae	0-15	7.5	0.6	0.3	93.5	1659.6	1.5	3.5	0.7	1.57	34.1	61.6	4.3
	15-30	7.1	1.5	0.2	106.9	1024.0	1.6	3.3	0.7	1.67	15.0	57.9	27.1
	30-60	7.0	4.1	0.3	30.8	635.6	2.1	3.6	0.8	2.03	30.1	49.2	20.7
Junco-Puccinellietum distans													
Eleocharietosum	0-15	8.3	5.3	3.5	35.0	600.3	2.3	7.0	1.5	2.26	76.1	13.5	10.4
	15-30	8.1	6.7	1.8	3.0	741.5	2.5	6.0	1.6	0.99	76.1	15.6	8.3
	0-1	8.0	2.1	1.0	78.1	1765.5	69.3	75.0	19.0	2.73	35.2	60.3	4.5
	0-15	8.3	9.5	1.3	72.0	2189.2	65.4	69.6	13.4	2.09	27.7	67.8	4.5
	15-30	8.3	12.5	6.0	3.0	1659.6	42.9	59.7	12.7	1.45	25.9	65.2	8.9
	30-45	8.3	9.8	5.2	16.4	1589.0	46.2	41.7	6.8	1.34	28.6	64.8	6.6
Lepidietosum	0-15	9.0	3.2	6.5	86.8	2930.7	39.6	43.6	7.7	1.57	17.6	60.0	22.4
	15-30	8.9	7.2	9.0	93.0	2012.7	27.0	35.2	5.4	1.04	15.2	67.7	17.1
Scorzoneretosum	0-15	8.3	5.0	2.1	4.1	1942.1	14.3	11.3	3.5	4.76	16.2	23.1	60.7
	15-30	8.2	3.3	3.3	16.4	2118.6	7.7	12.8	1.5	4.28	9.1	27.6	63.3

Asagi Camurlu villages located around 840 m altitude. Soil surface of this site was partly covered by white salt crust. Soil properties where this association participated predominantly may be seen from Table 1. Soil properties were as severe as the first association had, but soil texture was slightly lighter, silty loam. The soil was poor in CaCO₃, organic matter and P content while it was rich in K content.

The association was characterised by the dominance of *Halimione portulacoides* and *Arthrocnemum glaucum* species. The cover percentage varied between 30 and 80%. The alliance *Alhagio-Suaedion microphyllae* placed in the association was represented by the species of *Brachiaria eruciformis*, *Suaeda altissima* and *Alhagio pseudalhagi*, which were known as dominant and frequently, seen ones. Number of species was more than that of the *Arthrocnemum* association reaching up to 11 in some sample plots. *Phragmites australis* among the participated species exhibited 80% frequency.

Halocnemo-salsolietum macerae nova association: The association was seen in the area between Babacan and

Hasanhan villages at the altitude of 840. Soil properties where this association took part was shown in Table 1. This site was also characterised by unfavourable soil conditions in respect to plant growth. Soil textures were loam, silty loam, silty clay loam. The lime content of the soil increased down the soil profile while the organic matter decreased. The soil was considered poor in P content but rich in K content.

The association was characterised by the species *Halocnemum strabillaceum*, *Salsola macera* and *Salicornia prostrata*. *Arthrocnemum glaucum*, among the characteristic species of *Salicornia crassa*, accompanying in high ratio. Typical species of *Alhagio-Suaedion microphyllae* alliance, namely *Alhagio pseudalhagi*, *Halanthium roseum*, *Suaeda microphylla* and *Salsola crassa*, were the most frequent among others. The cover ratio of the association ranged from 25 to 75% and number of species varied between 3 and 8.

Kochio-Schismetum arabicum Nova association: This association was predominantly distributed in the area surrounded by Karahacili, Kulukent and Yukari Toprakli

villages whose average altitude was around 850 m. Because this area was bordered with the wind erosion area on the skirt of Ararat Mountain, soil surface was partly covered by volcanic ashes carried by the wind. Table 1 shows that the area has not serious salinity, alkalinity and boron problem. Soil texture may be classified as clay loam. CaCO_3 content was quite low while P, K and B content increased towards the soil surface.

The association was characterised by the species *Kocio prostrata* and *Schismus arabicus*. *Suaeda microphylla*, which is the typical species of *Alhagio-Suaedion* alliance in this association, was found to be dominant and frequent. Because the salinity of the soil was low, *Logfia arvensis* and *Senecio vernalis* among steppe type vegetation had the high ratio of frequency. The association took part in the transition zone between saline-alkaline and erosion regions. Cover rate of the association varied between 20% and 60% whereas the number of species ranged from 6 to 10.

Panderino-tamaricetum parviflorae nova association:

It was widespread in a small area between the villages of Karahacili and Yukari Toprakli where the saline and alkaline soils met the wind erosion area. Soil texture was medium, mainly loamy and silty loam. Groundwater table was deeper in this area than that of the other parts of the plain because the area located relatively at the higher place, at the skirt of Ararat Mountain. As a result of wind erosion volcanic ashes covered the soil surface slightly in some part of this area and therefore salt concentration was found to be quite low on the soil surface in Table 1. In general, the soil was slightly saline and poor in CaCO_3 , organic matter and plant nutrition element contents. However these did not limit the crop production.

Tamarix parviflora, *Panderia pilosa* and *Atriplex hastata* species represented the association in the defined area. *Alhagio-Suaedion* alliance of this association was presented by the species *Alhagi pseudalhagi* only. Species such as *Malva neglecta*, *Sisymbrium loeseli*, *Lepidium vesicarium* and *Senecio vernalis* grown under non-saline condition become common in the association since the salt concentration in the area was not high. The coverage of *Tamarix parviflora* in the shrub form was very high, between 60 and 95% while it was very small for the association, 5 - 15% and the number of species were between five and 15.

Junco-puccinellietum distans nova association: This association was come across on slightly salty marches accompanying with shallow water table between Asagi Camurlu-Ramazankent and Babacan-Hasanhan villages, as seen in Table 1. The texture of the soil in this area varied

from clay to clay loam and silty loam. The soil was moderate in CaCO_3 content however poor in P and K content. The area has boron problem.

The association was represented in the area by the species *Juncus gerardi* and *Puccinellia distans ssp. sevagensis*. The cover ratio of the association changed between 60 and 100% while the number of species varied from 2-8. The frequency of *Phragmites australis* and *Lotus corniculatus var. corniculatus* in the association was high. Three sub-associations, namely *Eleocharietosum uniglumis-mitracarpae*, *Lepiolietosum cartilagineum* and *Scorzoneretosum canae*, were described in this association. The first one was characterised by the species growing on marshes between Camurlu and Ramazankent villages, *Eleocharia uniglumis-mitracarpa*, *Bolboschoenus maritimus var. maritimus* and *Bramus racemosus*. The second one prevailed on the grassland in the south of Hasanhan village and represented by *Lepidium cartilagineum ssp. crassifolium*. The coverage of this sub-association was 100%. The last one was seen on the wet grassland between Hasanhan and Babacan villages and characterised by *Scorzonea cana ssp. cana*, *Centaureum tenuiflorum ssp. acutifolium*, *Carex divisia* and *Glaux maritima*.

Six plant associations in term of vegetation description represented Igdir Plain. *Arthrocnemum glaucum*, *Halimiono-Arthrocnemum glaucum* and *Halocnema-Salsolietum macerae* associations were quite widespread where the soil surface was mostly covered by white salt crust and B content reached very high levels.

Arthrocnemum association characterised by the dominancy of *Arthrocnemum glaucum* species was first described by Chapman^[7]. The species *Halocnema strabillaceum* and *Halimione portulacoides* representing above associations form different associations in the Central Anatolian alkaline and saline soils^[10-12]. Because sheep and goats continuously grazed the plants in the associations, species such as *Cynodon dactylon* and *Brachiaria eruciformis* did not grow over the level of soil surface.

Kachio-Schismetum arabicus and *Panderio-Tamaricetum parviflorae* associations were seen in the transition zone from the wind erosion area placed at the skirt of Ararat Mountain to the highly saline and alkaline area. Therefore species in these associations varied from halophyte such as *Suaeda microphylla*, *Halanthium roseum* and *Halocnema strabillaceum* to non-halophyte such as *Malva neglecta*, *Lepidium vesicarium*, *Senecio vernalis* and *Sisymbrium loeseli*.

Characteristic species of *Junco-Puccinellietum distans* association, *Juncus gerardi* and *Puccinellia*

distans, can form different associations growing on saline marshes. These are come up in England, Scandinavia and Poland^[7]. A research done in the saline and alkaline marshes in the Netherlands showed that while *Puccinellia maritima* decreased since they were crushed down and grazed by the cattle, *Juncus gerardi* and *Juncus maritimus* placed by time^[13]. *Juncus gerardi* took part with the decrease of *Puccinellia distans* in Iğdir Plain, especially between Asagi Camurlu and Ramazankent villages.

All the associations in the research area except *Arthrocnemum glaucum* was first identified in this study. *Junco-Puccinellietum* association among them was included in the *Salicornietea clasis* and the *Puccinellia-Salicornion europeae* alliance placed under the ordo of *Salsola-Aeluropetalia littoralii*. Other plants were grouped under the alliance of *Alhagio-Suaedion microphyllae*, which was described first in this study. The characteristic species of this alliance were *Alhagi pseudalhagi*, *Euaede microphylla*, *Suaeda altissima*, *Halanthium roseum*, *Salsola crassa* and *Brachiaria eruciformis*.

The vegetation of Iğdir Plain was arranged in the following order:

- Clasis : *Salicornietea herbaceae*
- Ordo : *Salsola-Aeluropetalia littoralii*
- Alliance 1 : *Puccinellia-Salicornion europeae*
- Association : 1. *Junco-Puccinellietum distans* Nova
- Alliance 2 : *Alhagio-Suaedion microphyllae*
- Associations : 1. *Arthrocnemum glaucum* Nova
- 2. *Halimiono-Arthrocnemum glaucum* Nova
- 3. *Halocnemo-Salsolietum macrae* Nova
- 4. *Kochio-Schismetum arabicum* Nova
- 5. *Panderino-Tamaricetum parviflorae* Nova

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