

Effects of Grazing on Soil Parameters in Meadow Ecosystems

Çayır Ekosistemlerinde Otlatmanın Toprak Parametrelerine Etkileri

Research Article

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ABSTRACT

This study was carried out to determine the effects of grazing on soil parameters in the meadow ecosystems in the alluvial delta plain of Samsun-Turkey. Five 5×5 m enclosures were established in the homogeneous stands in terms of habitat conditions and floristic composition in the study area during 2000-2003. The top of soil was firstly removed and then soil samples were taken from inside and outside of enclosures at a depth of 20 cm in each month for a year. Soil organic matter, pH, nitrogen, phosphorus, potassium, CaCO₃ and total salinity were measured by standard methods. In general, CaCO₃ and total salinity exhibited statistically significant differences between the grazed and ungrazed parts.

Key Words

Ecosystem, meadow, soil, Samsun.

ÖZET

Bu çalışma Samsun-Türkiye'de alüvyal delta ovalarındaki çayır ekosistemlerinde otlatmanın toprak parametrelerine etkilerini belirlemek için yürütülmüştür. 2000-2003 yıllarında 5×5 m lik beş adet eksklosür çalışma alanında floristik bileşim ve habitat koşulları bakımından homojen alanlarda kurulmuştur. Toprak örnekleri eksklosürlerin içerisinden ve dışından olmak üzere en üst toprak yüzeyi uzaklaştırıldıktan sonra 20 cm derinlikten bir yıl boyunca aylık olarak alınmıştır. Toprak organik maddesi, pH, azot, fosfor, potasyum, CaCO₃ ve toplam tuzluluk standart yöntemlerle ölçülmüştür. Genellikle CaCO₃ ve toplam tuzluluk otlatılan ve korunan kısımlar arasında istatistiksel olarak önemli derecede farklı çıkmıştır.

Anahtar Kelimeler

Ekosistem, çayır, toprak, Samsun.

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INTRODUCTION

Grazing is known to be an important biotic factor affecting the biomass and soil characteristics with the studies on meadow ecosystems in the worldwide [1-3]. Johnston et al. (1971) [4] reported that the long-term intensive grazing with cattle converted the soil pH from 5.7 to 6.2, the color of Ah horizon from black to dark brown, and reduced the soil organic matter, moisture and total phosphorus while increased available phosphorus and soil temperature in *Festuca* sp. meadow ecosystems. The results of soil analysis indicated to decrease in pH and moisture in the heavy grazing meadow [5].

The climate, landform, soil and living organisms have continuously influenced the meadow ecosystems. Meadow vegetation and grazing livestock constitute the complex components of an ecosystem. Therefore, it should be investigated not only the flora and vegetation of the meadow, but also the effects of grazing on the soils.

Although there have been many studies to investigate the grazing impact on the ecosystem's basic functions such as primary productivity, floristic composition and soil properties in the worldwide, there is almost no work on this sense in our country. We conducted this study in order to demonstrate the impact of grazing on the soil parameters in the lowland meadow ecosystems in the Middle Black Sea Region.

MATERIALS AND METHODS

Study Area

The study area is situated on the coastline of the Central Black Sea Region in the north of Turkey (Figure 1). The natural alluvial grasslands exist in the Central Black Sea Region adjacent to Kızılırmak and Yeşilirmak rivers, respectively. These large areas have been grazed and mowed since 1900's traditionally, but there hasn't been any management or conservation study in the area. This area floristically belongs to the Euxine province of the Euro-Siberian phytogeographical region. The studied grasslands are used as rangeland. The mean annual temperatures in the Kızılırmak and Yeşilirmak deltas are 13.66°C and

14.30°C respectively. The annual rainfall is 672.41 and 922.10 mm in the Kızılırmak and Yeşilirmak deltas respectively.

The study area consists of alluvial sediment soils carried by the Kızılırmak and Yeşilirmak rivers. Soil is typically dark grayish brown (Vertisol) and soil depth is meanly 1 m [6]. On average, soil texture is 48% clay, 33% silt and 19% sand.

The natural vegetation on the area is distributed by temperate grasslands of which consisted by three plant associations [7]. The vegetation in the study area is strongly affected by long-term and over-grazing. Grasslands in the western part of the study area are composed of herbaceous perennial mesophytic and xerophytic species, such as *Hordeum geniculatum* All., *Polypogon monspeliensis* (L.) Desf., *Centaurium pulchellum* (Sw.) Druce and *Romulea ramiflora* Ten. subsp. *ramiflora*, *Cynodon dactylon* (L.) Pers. var. *dactylon*, *Lotus corniculatus* L. var. *tenuifolius* L., *Bellis perennis* L., *Plantago lanceolata* L., *Lolium perenne* L., *Trifolium physodes* M.Bieb. var. *physodes* and *Medicago disciformis* DC. In the eastern part of the study area, grassland vegetation is composed of more herbaceous perennial mesophytic species, such as *Paspalum distichum* L., *Ranunculus ophioglossifolius* Vill., *Trifolium repens* L. var. *repens*, *Lolium perenne*, *Cynodon dactylon* var. *dactylon*, *Plantago lanceolata*, *Potentilla reptans* L. and *Rumex acetosella* L.

Soil Sampling, Analysis and Data Processing

Five localities were selected to obtain the soil samples. One floristically homogeneous permanent plot of (5×5 m) was selected and fenced in each stand in 2000 to take soil samples. So, totally five exclosures established to protect from grazing on studied meadows. The grazing sites have been continuously uncontrolled grazed for at least 20 years before building the exclosures by the horses, cows, sheep and goats, and were not burned the last 15 years.

Since nutrients are concentrated mainly on the topsoil [8], we sampled only the upper 20 cm of the A1 horizon. Throughout a year, soil samples

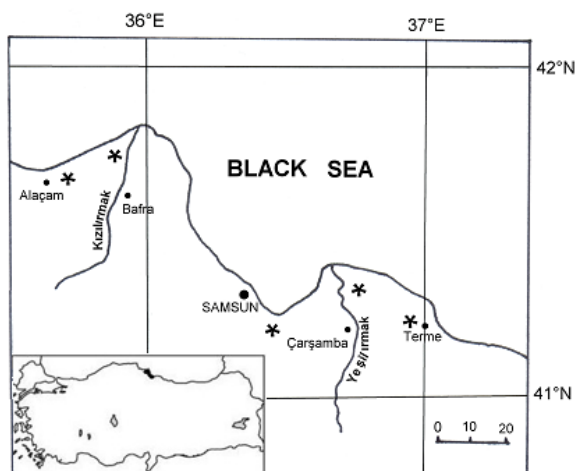


Figure 1. Map of the study area. * Selected stands.

(four samples per month) were taken both inside and outside of exclosures at each locality. The soil samples were air dried for 48-72 h and sieved through a 2 mm sieve before the chemical analyses [9,10].

Electrical conductivity (dS.m^{-1}) was determined in soil-water extracts at 1:1 (w:w) using a Jenway analyser and converted to the percentage of the total salinity. pH values were measured in deionized water (1/1). Soil nitrogen (%) was determined by micro Kjeldahl method. Soil phosphorus (%) was determined spectrophotometrically following the extraction by ammonium acetate. Soil potassium (%) was determined by using a Petracourt PFP-7 flame photometer after nitric acid wet digestion. CaCO_3 (%) concentrations were determined by using a Scheibler calcimeter [9].

Descriptive statistical analyses were performed by using SPSS 21.0 version [11]. The data obtained from grazing and ungrazing parts were evaluated with one-way analysis of variance (ANOVA) and Pearson's correlation test.

RESULTS

Grazing livestock units (BBHB) and area (ha) of the different localities were showed in Table 1 by using data of Samsun Provincial Directorate of Agriculture. According to Table 1, there were heavy grazing intensity in Tekkeköy, Çarşamba,

Terme and Bafra respectively, but there was no statistical data about Alaçam. However, the number of grazing animals such as geese and wild horses have also been observed during our field work in the studied stands. Furthermore, after October, the migration of sheep breeders was observed from high plateau to lowland meadows to spend the winter with many sheep in Bafra. So, we think that the grazing pressure can be higher than the calculations made on the basis of official data.

In general, there were statistically significant differences in terms of CaCO_3 and total salinity between grazing and ungrazing soils (Table 2). When the data were annually evaluated, soil salinity and CaCO_3 contents were higher in grazing than ungrazing meadow ecosystems in the study area (Figure 2). Conversely, soil pH was high at grazing lands, amounts of soil organic matter were high at ungrazed stands (Figure 3). When we seasonally investigated the effects of grazing, soil CaCO_3 for all seasons while soil total salinity at winter and summer significantly changed (Table 3) and both of them were higher in grazing parts (Figure 4).

Beside, the nitrogen content of the soil in the spring, the phosphorus content also showed significant differences in fall depend on grazing (Table 3). Soil nitrogen and phosphorus contents were generally higher in ungrazed stands than grazed (Figure 5).

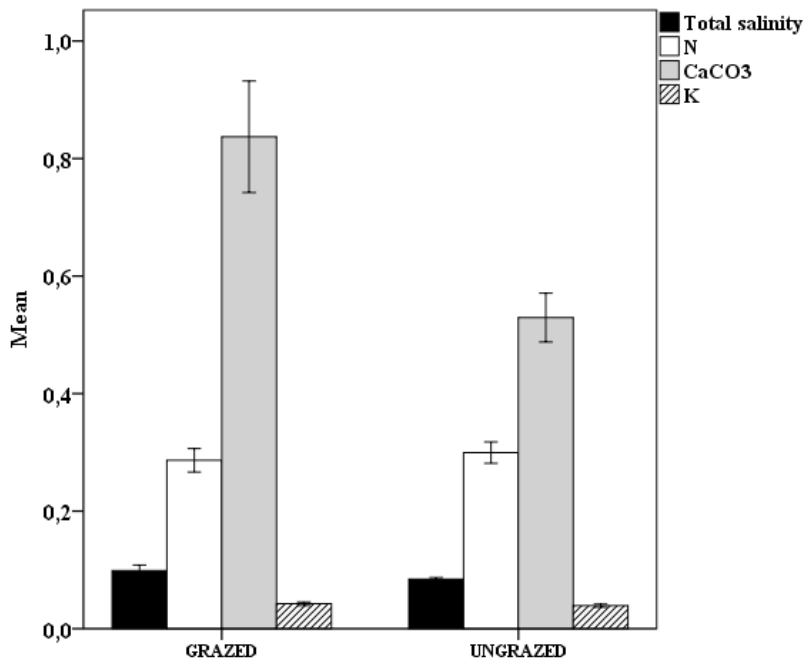


Figure 2. The annual average values of the total soil salinity, nitrogen, calcium carbonate and potassium between grazed and ungrazed stands of the study area (n=48).

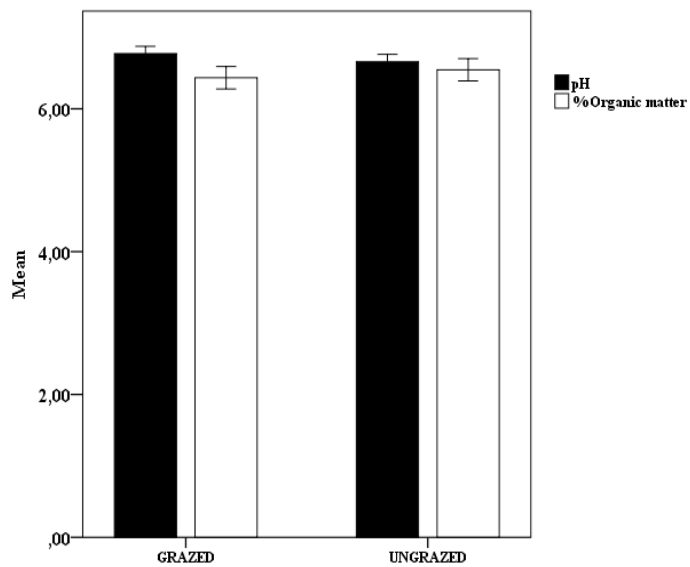


Figure 3. The annual average values of the soil pH and organic matter between grazed and ungrazed stands of the study area (n=48).

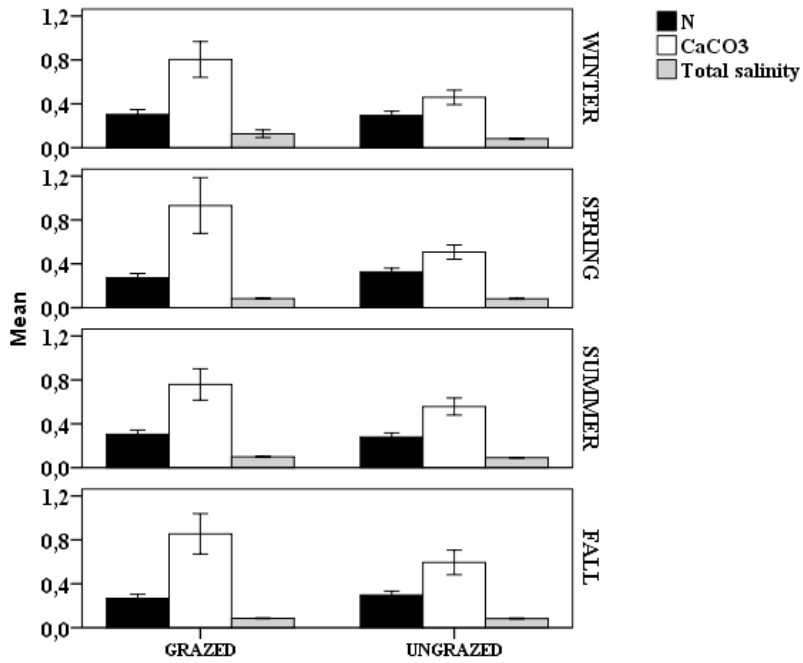


Figure 4. The seasonal average values of the total soil salinity, nitrogen, calcium carbonate and potassium between grazed and ungrazed stands of the study area (n=12).

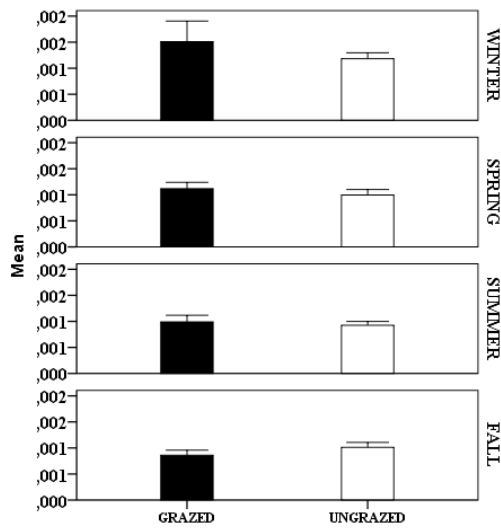


Figure 5. The seasonal average values of the total soil phosphorus between grazed and ungrazed stands of the study area (n=12).

Table 1. The study area (ha), the number of grazing animals (BBHB) and grazing intensity (BBHB/ha).

Localities	Area (ha)	Culture Crossbreed			Native			Male Water Buffalo	Female Water Buffalo	Sheep	Goat	Lamb/Kid	Total (HBBB)	Grazing intensity (BBHB/ha)
		Bull	Cow	Calf	Bull	Cow	Calf							
Alaçam	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Bafra	22.10	-	547	300	-	-	-	23	111	165	-	-	673.3	30.46
Çarşamba	13.36	-	-	-	-	698	474	29	75	798	52	599	703.31	52.64
Terme	13.62	-	80	13	-	575	83	-	-	80	-	-	448.45	32.92
Tekkeköy	10.94	-	426	400	-	-	-	-	-	1650	-	-	725	66.27

Table 2. Annual comparison of soil parameters by using one-way variance analysis (ANOVA) between grazing and ungrazing parts.

Solid Parameters			df	Mean Square	F	Sig.
N	Between Groups	0.01	1	0.01	0.93	0.33
	Within Groups	6.66	382	0.01		
	Total	6.68	383			
P	Between Groups	0.01	1	0.01	2.03	0.15
	Within Groups	0.01	382	0.01		
	Total	0.01	383			
K	Between Groups	0.01	1	0.01	2.52	0.11
	Within Groups	0.15	382	0.01		
	Total	0.15	383			
CaCO ₃	Between Groups	9.08	1	9.08	35.26	0.01*
	Within Groups	98.42	382	0.25		
	Total	107.50	383			
pH	Between Groups	1.22	1	1.22	2.43	0.12
	Within Groups	192.43	382	0.50		
	Total	193.66	383			
Organic Matter	Between Groups	1.18	1	1.18	1.01	0.31
	Within Groups	450.18	382	1.17		
	Total	451.36	383			
Total	Between Groups	0.02	1	0.02	9.13	0.01*
	Within Groups	0.84	382	0.01		
	Total	0.86	383			

(*P<0.01)

Table 3. Seasonal comparison of soil parameters by using one-way variance analysis (ANOVA) between grazing and ungrazing parts.

Season	Soil Parameters		Sum of Squares	df	Mean Square	F	Sig.
Winter	CaCO ₃	Between Groups	2.86	1	2.86	15.52	0.01*
		Within Groups	17.33	94	0.18		
		Total	20.20	95			
	Total Salinity	Between Groups	0.04	1	0.04	6.69	0.01*
		Within Groups	0.68	94	0.01		
		Total	0.73	95			
Spring	N	Between Groups	0.06	1	0.06	4.29	0.04**
		Within Groups	1.49	94	0.01		
		Total	1.56	95			
	CaCO ₃	Between Groups	4.31	1	4.31	10.46	0.01*
		Within Groups	38.71	94	0.41		
		Total	43.02	95			
Summer	CaCO ₃	Between Groups	0.97	1	0.97	6.14	0.01*
		Within Groups	14.84	94	0.15		
		Total	15.81	95			
	Total Salinity	Between Groups	0.01	1	0.01	6.06	0.01*
		Within Groups	0.03	94	0.01		
		Total	0.03	95			
Fall	P	Between Groups	0.01	1	0.01	5.09	0.02**
		Within Groups	0.01	94	0.01		
		Total	0.01	95			
	CaCO ₃	Between Groups	1.62	1	1.62	5.83	0.01*
		Within Groups	26.24	94	0.27		
		Total	27.86	95			

*P<0.01; **P<0.05

Table 4. Pearson correlation coefficients between soil parameters of grazing and ungrazing parts.

Practice	Soil Parameters	N	P	K	CaCO ₃	pH	Organic Matter	Total Salinity
Grazing	N	-	-0.06	-0.18*	0.52**	0.30**	0.12	-0.01
	P	-0.06	-	0.14	-0.05	0.09	-0.17*	-0.05
	K	-0.18*	0.14	-	0.05	0.45**	-0.37**	0.05
	CaCO ₃	0.52**	-0.05	0.05	-	0.72**	-0.17*	-0.08
	pH	0.30**	0.09	0.45**	0.72**	-	-0.50**	-0.14*
	Organic Matter	0.12	-0.17*	-0.37**	-0.17*	-0.50**	-	0.01
	Total Salinity	-0.01	-0.05	0.05	-0.08	-0.14*	0.01	-
Ungrazing	N	-	-0.04	-0.38**	-0.19**	0.06	0.34**	-0.36**
	P	-0.04	-	0.52**	-0.11	0.08	-0.16*	0.08
	K	-0.38**	0.52**	-	0.46**	0.54**	-0.54**	0.59**
	CaCO ₃	-0.19**	-0.11	0.46**	-	0.79**	-0.42**	0.65**
	pH	0.06	0.08	0.54**	0.79**	-	-0.47**	0.54**
	Organic Matter	0.34**	-0.16*	-0.54**	-0.42**	-0.47**	-	-0.24**
	Total Salinity	-0.36**	0.08	0.59**	0.65**	0.54**	-0.24**	-

* P< 0.05. ** P<0.01

The number of negative correlations were more than positive correlations that exhibited by the soil parameters between grazing and ungrazing lands (Table 4). In grazed parts, soil nitrogen showed positively correlation with soil pH and CaCO₃, while there was a negative correlation among of soil nitrogen, total salinity and CaCO₃, in ungrazed parts. Similarly, there was only positive correlation between soil P and K in protected parts. There was a negative correlation in grazed parts while positive correlation in ungrazed parts between soil pH and total salinity. A positive correlation was observed between the soil organic matter and nitrogen in ungrazed parts (Table 4).

DISCUSSION

Grazing affects the amount of soil nutrients in meadow ecosystems. This effect may be in different ways such as trampling, biomass consumption and accumulation of feces. Sometimes, the literature has been contradictory about grazing effects on the soil organic matter

and nutrient status [12]. The reasons are different environmental conditions and grazing regime. Therefore, it is very difficult, to make a precise definition between the effects of grazing and the availability of soil organic matter and nutrients. Still, it has been accepted in a meadow ecosystems that the increases of available nitrogen and phosphorus consist via to defecation of grazing animals while the losses occur due to erosion, washing or nutrient circulation between soil and plants [12-14]. Annually, our data also support these conclusions while seasonally contradict.

It has been reported that grazing increase the soil nitrogen ratio in many studies [12,15,16]. However, the amount of nitrogen in the soil is related to the age of the land. The youngest landscape has lower while the oldest has high soil nitrogen [17]. The amount of soil organic matter and nitrogen exhibit positive correlation that confirms to decompose organic matter. Naeth and Chanasyk (1995) [18] reported that both grazing and seasonal changes affect the amount

of organic matter in the meadow ecosystem soils. The organic matter in the meadow ecosystem soils is used both phosphorus and nitrogen mineralization as an important source [15]. The season of began to decline in plant growth rate will exceed the rate of mineralization of nitrogen that increases amount of nutrient uptake in the meadow soils [19]. Our data supported that both the amount of organic substances and consequently vary the quantity of nitrogen and phosphorus at ungrazed stands in some seasons.

In grazing parts of the study area, phosphorus content was high as similar to nitrogen. The high phosphorus content often seen depending on grazing in the meadow soils. Because, an adult cattle meanly produces 25 kg of feces and urine 9 kg per day, and fresh cattle feces and urine averagely consist of 0.18% and 0.01% P_2O_5 , respectively [20]. Moreover, soil phosphorus is one of the main components of the organic material and is provided almost entirely from the bedrock. Increasing grazing pressure is also effective on soil phosphorus content in this study [16].

pH decreases from west to east in the study area. The reason is that the soils are washed with increasing precipitation. pH acts as a indicator for two basic nutrients in the soil. These elements are Ca and Mg. Calcium ensures the nutrients absorption and cations selection from soil and it is one of the important indicators of soil fertility [21]. Ca content decreases in asidic soil, so, $CaCO_3$ ratio decreased in the east of study area. Grazing animals affect meadow ecosystem soils via to trampling compacts and increases bulk density [22]. In such soils, $CaCO_3$ doesn't move away by washing and its concentration increases [23]. This process supports our results.

There are a number of study to evaluate the soil salinity in terms of the seasonality, grazing, and vegetation relationships in the meadow ecosystem [24]. Usually the soil salinity in the ungrazed plots is higher than in grazed. Grazing reduces the plant coverage and litter, so it is observed to increase in evaporation from soil via to raising soil temperature in the meadow

ecosystems [25,26]. Especially in spring and summer, we observed that the total salinity of upper soil layer increased in grazing stands.

CONCLUSION

In this study, grazing has led to a statistically significant annual and seasonal changes in which we measure some of the soil parameters. It is important that controlled grazing should be done to sustainable use the primary production and conservation of biodiversity in meadow ecosystems used as rangeland.

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