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Research Article / Araştırma Makalesi

# Effect of rotational grazing on some soil properties in Düzce of Turkey

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**Abstract:** Pastures, one of the four important vegetation types in the world, have great potential not only in terms of forage production for animals, but also in terms of biological diversity. Yet, the pressure of continuous and overgrazing on pastures in Turkey affects both vegetation and soil negatively. Overgrazing leads to soil compaction, thus, soil permeability is influenced in a negative way. It is possible to remove these negative influences via amendment methods or reorganizing grazing. In this study, it was researched how short duration rotational grazing influenced some soil properties in a pasture where uncontrolled heavy grazing for many years in Düzce. As a result of the study, soil properties affected by rotational grazing at most were permeability and bulk density. While the value of bulk density increased from 1.19 gr cm-3 to 1.30 gr cm-3 in the continuous grazing pastures, it decreased from 1.38 gr cm-3 to 1.26 gr cm-3 in the rotational grazing pastures. It was demonstrated in the study that organizing grazing systems in the pastures can improve soil permeability and bulk density to a great extent.

**Keywords:** Rotational grazing, bulk density, permeability, pasture

# Düzce yöresinde münavebeli otlatmanın bazı toprak özellikleri üzerine etkisi

**Özet:** Dünyadaki dört önemli vejetasyon tipinden bir olan meralar hayvanlara kaba yem temin etmenin yanı sıra biyolojik çeşitlilik açısında da önemli bir potansiyele sahiptir. Ancak ülkemizde mera alanları üzerindeki düzensiz ve aşırı otlatma baskısı gerek bitki örtüsü gerekse toprak üzerinde olumsuz etkiler oluşturmaktadır. Aşırı otlatmayla birlikte toprak sıkışması olmakta ve toprakların su geçirme özelliği olumsuz etkilenmektedir. Bu olumsuz etkiler mera alanlarında uygulanacak ıslah yöntemleri veya otlatmanın düzenlemesi ile düzeltilebilmektedir. Bu çalışmada da Düzce ilinde uzun yıllar kontrolsüz bir şekilde ağır otlatma yapılan bir mera alanında kısa süreli münavebeli otlatmanın bazı toprak özellikleri üzerine etkisi araştırılmıştır. Araştırma sonucunda münavebeli otlatmadan en fazla ve hızlı etkilenen toprak özellikleri geçirgenlik ve hacim ağırlığı olmuştur. Nitekim hacim ağırlığı değeri 3 yılın sonunda sürekli otlatılan alanda 1,19 gr cm-3 den 1,30 gr cm-3 değerine çıkarken; münavebeli otlatma yapılan alanlarda 1,38 gr cm-3 den 1,26 gr cm-3 düzeyine düşmüştür. Araştırma mera alanında otlatmanın düzenlenmesi ile toprakların geçirgenlik ve hacim ağırlığı özelliklerinde önemli iyileşmelerin olabileceğini ortaya koymuştur.

**Anahtar Kelimeler:** Münavebeli otlatma, hacim ağırlığı, geçirgenlik, mera

## 1. INTRODUCTION

Pastures, one of the four important vegetation types in the world, are significant natural resources with regard to the environment and ecosystem. They have potential resources for providing coarse fodder for animals, biological diversity, soil and water conservation, recreation areas and providing habitat for wild animals (Altin et al., 2011; Unal et al., 2014). As long as used in a planned and careful way, it is possible to take constant and optimum advantage of pastures.

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Pasture areas have decreased for last sixty years in Turkey, reaching 60 %. The pasture areas which were 37.9 million hectares in 1950 declined to 14.6 million hectares in 2016 (TUIK, 2016). The most important factors in this decline are The Pasture Law numbered 4342 enacted in 1998 and lack of legal arrangements about pasture areas. Upon this decline, while 3.38 hectares of pasture area accrued for an animal unit (AU) in 1940, this ratio regressed to 1.24 hectares in 2009 (Kusvuran et al., 2011). This raised the pressure of grazing in pasture areas. This increase influences vegetation and soil in pasture ecosystems in a negative way (Li et al., 2008). Decline in vegetation and changes in hydro-physical properties of soil are the leading negative effects. Increase in the grazing pressure causes soil compaction in pasture areas leading to increase of bulk density, thus, decrease of permeability (Pei et al., 2008; Stavi et al., 2008; Du Toit et al., 2009; Cetiner et al., 2012). This situation causes erosion to increase in especially sloping pastures with weak vegetation (Schönbach et al., 2011; Wilkinson et al., 2013). Compaction also have negative effects on plant root development in pastures and root development is limited when the bulk density exceeds the value of 1,85 gr cm-3 (Pierce et al., 1983).

This unfavourable case in pasture lands can be improved via rotational grazing or being protected from grazing for a certain period. This is also stated in several works (Yong-Zhong, et al., 2005; Drewry, 2006; Steffens et al., 2008; Mekuria, 2013). Wu et al. (2014) expressed that permeability ratio was higher in pasture lands protected from grazing for 15 years than in pasture lands protected from grazing for 5 years. Li et al. (2011) measured lower bulk density value in exclosure pasture than continuous grazed pasture. In Turkey, Cetiner et al. (2012) stated that bulk density of lands increased and total pore space decreased as a result of grazing in sown pasture for 2 years. Kuvvet (2014) stated that soil compaction value in the areas closed to grazing was lower than the areas open to grazing in all soil depths in Alpine Pastures in Trabzon Province.

The aim of this study is to determine the influence of short duration rotational grazing in a pasture area grazed in an uncontrolled and heavy way for a long time on some hydro-physical (bulk density, permeability, saturation capacity, texture, loss on ignitation) and chemical (pH and electrical conductivity) soil properties.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out in Karadere Hasanaga village pasture in Düzce Province located in the Black Sea region between 2011 and 2013. The pasture area is located at 40º50'08" - 40º50'23" N and 31º04'14" 31º04'30" E, 127 m asl (above sea level) and 15.3 ha (Figure 1).

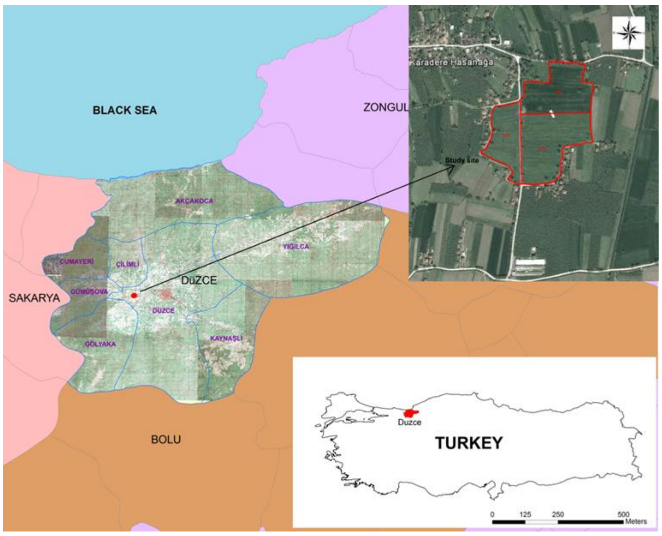



Figure 1. Location map of the study area.
Şekil 1. Çalışma alanı

Düzce Province has a climate type similar to oceanic climate which has medium water deficit in humid, mesothermal summer. Average yearly rainfall is 818.4 mm and most of it falls in October and March.

Average yearly temperature is 13.2 ºC. The coldest month of the year is January with 3.9 ºC and the hottest month is July with 22.6 ºC. Pasture area consists of productive alluvial soil and large-scale groundwater (Yavuz, 2013).

### 2.2 Sample collection and analysis

At the beginning of grazing period in 2011, the pasture area which had been exposed to uncontrolled and heavy grazing for long years (0.12 ha Au-1), the suitable amount of which is 0.61 ha Au-1 (Altin et al., 2011), was divided into three plots of 2.93, 5.43 and 4.09 ha by Düzce Directorate of Provincial Food Agriculture and Livestock. From this year on, the plot of 2.93 ha (Plot I) has been grazed by 40 male cattle (0,07 ha Au-1) without any rotation for 150-day grazing period. The other plots of 5.43 (Plot II) and of 4.09 (Plot III) have been grazed by 60 female cattle ( Plot II 0.09 ha Au-1 and Plot III 0,06 ha Au-1, respectively) with a 25-day rotation for 150-day grazing period. First soil samples were taken at the beginning of grazing period in 2011 before above-mentioned grazing plan started and afterwards the grazing plan started to be implemented. Soil samples from the same areas were taken at the beginning of grazing period in 2012 and 2013 (the samples are collected at the end of May of each year) to analyze the effects of the grazing plan on hydro-physical properties of the pasture land. 9 soil core and bag samples were taken from each plot at 0-20 cm soil depths and 9 from 20-40 cm soil depths (18 samples). So, 54 (3x18) soil samples were taken in the whole study area (Figure 2).

Figure 2. Grazing in the pasture and taking soil samples
Şekil 2. Mera alanındaki otlatma ve toprak örneklerinin alınması

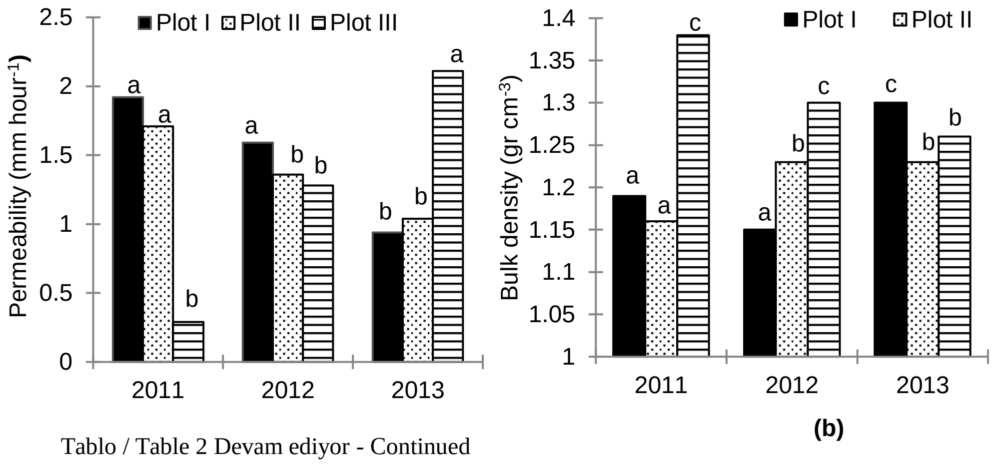
Analyses of permeability, saturation capacity, bulk density, texture, as loss on ignition of organic matter, pH and electrical conductivity were made on the soil samples.

The Darcy equation was used to determine permeability of the soil core samples. The weight of saturated soil samples that underwent the permeability test was determined. Afterwards, they were dried at 105 ºC and their dry weight was stated. Saturation capacity and bulk density of the soil samples were found out thanks to wet weight, dry weight and cylinder volume (Ozyuvaci,1976). Texture was determined via Bouyoucos hydrometer method on the soil samples sifted through 2 mm sifter. Organic mattter was determined as percentages by burning of soil samples at 600-700 ºC (Gulcur, 1974). Electrical conductivity and soil pH (soil/water ratio of 1/2.5) measurements were made via Hach Lange HQ40D dual duct digital multi parameter measuring device (Gulcur, 1974).

The influence of the grazing plan on hydro-physical properties on pasture lands was tested via variance analysis and averages were compared via Duncan test.

## 3. RESULT AND DISCUSSION

Hydro-physical properties of the soils in testing site were respectively evaluated as topsoil and subsoil. In accordance with the grazing plan, change in the permeability of topsoil was found statistically significant according to year and plot (P<0.05), the lowest permeability value was 0,29 mm $h^{-1}$ in 2011 in Plot III, the highest permeability value was 2,59 mm $h^{-1}$ in 2013 in again Plot III (Figure 3a). Thanks to the grazing plan, changes in bulk density of top soils of grazing plots were found statistically significant (P<0.05). According to year and plot, the lowest bulk density was 1.15 gr $cm^{-3}$ in 2012 in Plot I, the highest bulk density was 1.38 gr $cm^{-3}$ in 2011 in Plot III (Figure 3b). Changes in electrical conductivity of the soils were found statistically significant (P<0.05) and electrical conductivity values reached the lowest value in three plots in 2013 (Figure 3c).

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Tablo / Table 2 Devam ediyor - Continued

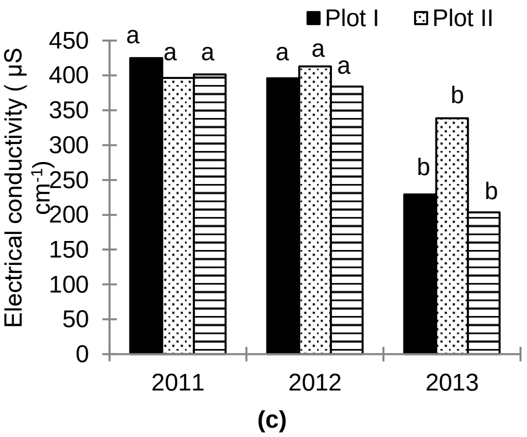


Figure 3. Average top soil permeability (a), bulk density (b) and electrical conductivity (c) values according to plots and years. Different letters indicate statistically significant differences between plots and years.

Şekil 3. Deneme parseli ve yıllara gore ortalama üstoprak permeabilite (a), hacim ağırlığı (b) ve elektriksel iletkenlik (c) değerleri. Farklı harfler deneme parseli ve yıllar arasındaki istatistiksel farklılığı göstermektedir.

Changes in saturation capacity (%), sand (%), silt (%) and pH (soil/water ratio of 1/5) values of top soils of sampling plots in the pasture land were not found statistically significant (P > 0.05) (Table 1).

Table 1. Average top soil values according to plots and years
Tablo 1. Deneme parseli ve yıllara göre ortalama üst toprak değerleri

| **Sampling plots** | **Years** | | |
|---|---|---|---|
| | **2011** | **2012** | **2013** |
| Saturation capacity (%) | | | |
| I | 42,2 ± | 38,4 ± 9,34 | 37,7 ± 4,10 |
| II | 36,4 ± | 38,3 ± 8,22 | 37,3 ± 3,63 |
| III | 38,7 ± | 40,6 ± 5,16 | 32,9 ± 4,16 |
| pH (soil/water ratio of 1 /2,5) | | | |
| I | 5,39 ± | 5,81 ± 0,32 | 5,73 ± 0,40 |
| II | 5,64 ± | 5,65 ± 0,23 | 5,51 ± 0,37 |
| III | 5,57 ± | 5,85 ± 0,15 | 5,67 ± 0,21 |
| Sand (%) | | | |
| I | 60,2 ± | 59,1 ± 2,50 | 59,7 ± 4,00 |
| II | 61,3 ± | 62,8 ± 2,67 | 61,4 ± 3,98 |
| III | 63,9 ± | 61,9 ± 4,95 | 63,2 ± 1,79 |
| Clay (%) | | | |
| I | 14,8 ± | 13,1 ± 2,15 | 14,5 ± 1,49 |
| II | 15,5 ± | 14,2 ± 2,15 | 16,6 ± 5,35 |
| III | 13,5 ± | 12,9 ± 3,02 | 14,0 ± 2,98 |
| Silt (%) | | | |
| I | 24,8 ± | 27,6 ± 2,78 | 25,6 ± 3,12 |
| II | 23,1 ± | 23,3 ± 2,23 | 21,8 ± 3,40 |
| III | 22,5 ± | 25,1 ± 2,47 | 22,6 ± 3,20 |
| Organic matter (%) | | | |
| I | 12,94 ± | 12,43 ±1,93 | 12,68 ± 2,38 |
| II | 12,41 ± | 11,96 ± 2,38 | 12,71 ± 2,42 |
| III | 12,90 ± | 12,26 ± 2,15 | 12,56 ± 2,06 |

The permeability value that was 0.04 mm h $^{-1}$ in Plot II in 2011 was measured as 1,20 mm h $^{-1}$ in 2013 (Figure 4a). While the bulk density values did not show any significant changes in Plot I, they decreased dramatically in Plot II and Plot III in 2012 and 2013 ($P<0.05$), respectively. Namely, the bulk density that was 1.49 gr cm$^{-3}$ in Plot III in 2011 decreased to 1.35 gr cm$^{-3}$ in 2013 (Figure 4b). When the influence of the procedures implemented in the pasture land on the hydro-physical properties of subsoils were analysed, it was observed that permeability values did not change in Plot I, but they increased dramatically in Plot II and Plot III in 2012 and 2013 ($p<0.05$), respectively.

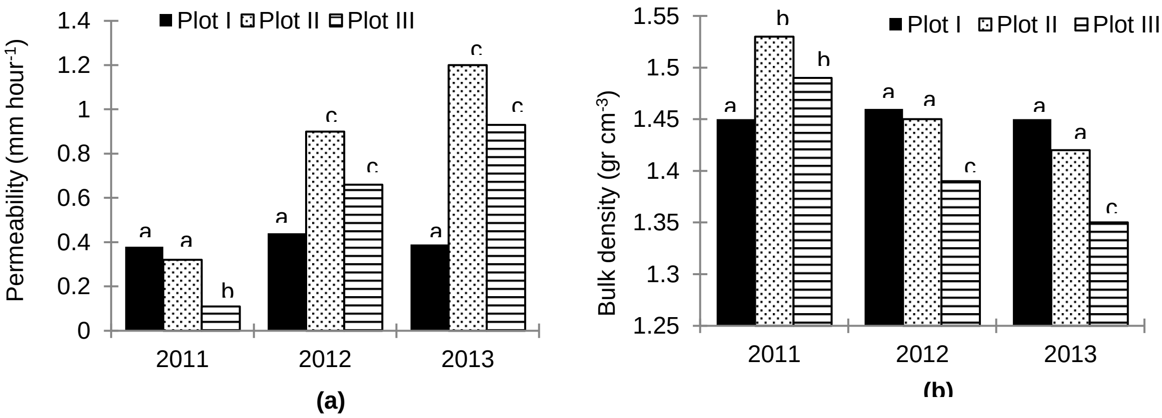


Figure 4. Average subsoil permeability (a) and bulk density (b) values according to plots and years. Different letters indicate statistically significant differences between plots and years.
Şekil 4. Deneme parseli ve yıllara göre ortalama alt toprak permeabilite (a) ve hacim ağırlığı (b) değerleri. Farklı harfler deneme parseli ve yıllar arasındaki istatistiksel farklılığı göstermektedir.

However, the changes in subsoil properties were not found statistically significant according to plots and years ($P > 0.05$) (Table 2).

Table 2. Average subsoil values according to plots and years
Tablo 2. Deneme parseli ve yıllara göre ortalama alt toprak değerleri

| Sampling plots | Years | | |
|---|---|---|---|
| | 2011 | 2012 | 2013 |
| Saturation capacity (%) | | | |
| I | 30,4 ± 2,93 | 31,8 ± 4,26 | 31,1 ± 4,99 |
| II | 25,8 ± 6,70 | 28,1 ± 3,46 | 29,1 ± 2,70 |
| III | 30,6 ± 5,02 | 29,8 ± 3,66 | 30,5 ± 4,24 |
| pH (soil/water ratio of 1 /2,5 ) | | | |
| I | 5,99 ± 0,18 | 6,34 ± 0,10 | 6,09 ± 0,50 |
| II | 5,91 ± 0,22 | 6,30 ± 0,31 | 5,97 ± 0,58 |
| III | 5,96 ± 0,36 | 6,26 ± 0,29 | 5,80 ± 0,19 |
| Electrical conductivity (μS $cm^{-1}$) | | | |
| I | 178,0 ± 51,54 | 177,9 ± 48,44 | 192,6 ± 65,17 |
| II | 177,5 ± 33,34 | 244,0 ± 80,86 | 168,0 ± 63,53 |
| III | 200,2 ± 63,97 | 164,4 ± 47,85 | 161,1 ± 51,42 |
| Sand (%) | | | |
| I | 52,4 ± 5,04 | 51,2 ± 1,99 | 51,6 ± 4,09 |
| II | 57,3 ± 3,87 | 58,7 ± 3,35 | 56,6 ± 3,50 |
| III | 55,1 ± 1,50 | 56,7 ± 2,96 | 55,1 ± 1,49 |
| Clay (%) | | | |
| I | 22,4 ± 1,26 | 19,5 ± 6,22 | 22,7 ± 1,03 |
| II | 18,9 ± 2,06 | 17,2 ± 2,96 | 18,7 ± 2,08 |
| III | 19,9 ± 1,74 | 19,4 ± 3,13 | 19,7 ± 1,29 |
| Silt (%) | | | |
| I | 25,1 ± 4,91 | 29,2 ± 4,73 | 25,5 ± 4,44 |
| II | 23,7 ± 2,77 | 24,0 ± 4,41 | 24,5 ± 2,12 |
| III | 24,8 ± 2,14 | 23,8 ± 2,75 | 25,1 ± 1,90 |
| Organic matter (%) | | | |
| I | 6,91 ± 2,37 | 6,38 ± 1,39 | 6,68 ± 1,91 |
| II | 5,99 ± 1,98 | 6,79 ± 1,55 | 6,14 ± 0,86 |
| III | 6,94 ± 1,01 | 6,97 ± 1,66 | 6,32 ± 0,93 |

The study that the grazing systems applied in the pasture lands affect some hydro-physical properties of the soils like permeability and bulk density to a great extent. While topsoil permeability values decreased according to years in Plot I grazed constantly, bulk density values increased. These findings comply with lots of study results putting forward if the grazing period and pressure increase, soil compaction increases too (Yong-Zhong et. al. 2005; Pei et. al. 2008; Stavi et al. 2008; Du Toit et. al. 2009, Cetiner et al. 2012). While permeability values of topsoils in Plot II grazed with a 25-day-rotation reduced by years, bulk density values increased, but Plot III where the same grazing plan was implemented had a reverse situation. This situation can be explained in such a way that grazing started firstly in Plot II in spring months in 2012 and 2013 and the land was moist in this period so it may have increased soil compaction. Hamza and Anderson (2005) indicated that impact of livestock trampling on compaction of soils generally increases as the soil moisture at the time of trampling increases and preventing grazing on wet soils was strictly suggested.

Depending on the grazing system applied in the pasture land, while changes with different ratios in short time were observed in permeability and bulk density values, no significant changes were observed in other properties (sand, clay, silt, saturation capacity, pH). Soil texture was the soil property influenced by changes in land use at least and not showing significant changes for many years (Ozhan, 2004). Saturation capacity of soils changed depending on especially soil texture and organic matter amount (Ozhan 2004). Although there were changes in saturation capacity of soils by years, these changes were not found statistically significant which can be mentioned by the fact that there was no change in soil textures and organic matter in the pasture lands. It was found out that electrical conductivity values were similar in 2011 and 2012 but they decreased dramatically in 2013. The reason for this is the high level of precipitation in the months before sampling in 2013, relative to the other years (TSMS, 2015) and sodium and potassium salts which are dissolvable cations could have been washed in the soil. However, electrical conductivity values (maximum value is 425 µS $cm^{-1}$) measured at different years at parcels of pasture land are not in a limiting level for pasture plants (Ekmekci et al. 2005). Electrical conductivity values of the soils can change according to several factors such as bedrock, climate, organic matter and dissolvable cation amount in the soil etc. (Corwin and Lesch, 2005).

## 4. CONCLUSION

The grazing methods employed in the pasture lands can affect plant production and composition in these areas. At the same time, these methods can influence hydro-physical properties of the soils in the pasture lands positively or negatively. In this study the influence of grazing methods applied in Karadere Hasanaga Village pasture land in Düzce Province on hydro-physical properties of pasture lands was researched.

It was stated that the grazing methods implemented in the pasture land influenced some hydro-physical properties of the soil like permeability and bulk density. The study has demonstrated that the time to start grazing was more effective on permeability and bulk density than grazing pressure. Although the grazing pressure in Plot III (0,06 ha $Au^{-1}$) was higher compared to Plot II (0,09 ha $Au^{-1}$) and the beginning (0,12 ha $Au^{-1}$), permeability and bulk density values of topsoil decreased due to starting grazing late in this plot. However, because there was higher grazing pressure in Plot I and Plot II in comparison with the first grazing method (0,12 ha $Au^{-1}$), permeability values of topsoil decreased and bulk density values increased by years.

After the grazing system was changed, there was no statistically significant change in other soil properties that were analyzed. While permeability and bulk density can react in a short time (2-3 years) depending grazing pressure and grazing time, the properties like sand, clay and silt quantity (texture), saturation capacity etc. can react in a longer time. In such studies, the changes in these properties can be determined extending the time.

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