# Grazing Effects on Soil Physical and Chemical Properties

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## Abstract

Uncontrolled grazing can have deteriorative effects on soil properties. This paper studied the effect of different grazing intensities on soil physicochemical and hydraulic properties at Al-Khanasry Agricultural Station, Al-Mafraq, Jordan. In summer 2016. Treatments were (1) no-grazing (NG), (2) controlled grazing (CG), and (3) uncontrolled grazing (UnG) sites. Soil samples were collected from each site to determine bulk density (BD), aggregate stability (AS), soil organic matter (SOM), electrical conductivity (EC), soil acidity (pH), and cation exchange capacity (CEC). Infiltration ($F_{(t)}$) and hydraulic conductivity (HC) were measured in the field. Results showed that UnG significantly increased BD, Controlled and un-controlled grazing sites showed similar BD (P=< 0.05), the highest was in controlled grazing (1.47 g $cm^{-3}$). Aggregate stability also increased under grazing condition (P=< 0.05) only in the surface layer (AS), The lowest AS in surface layer was observed in no-grazed plot (17.4%), while no significant difference (P=< 0.05) were observed between controlled and un-controlled grazing plots (24.6 and 24.8%), respectively. In significant (P=< 0.05) Grazing increased soil OM in surface layers. Un-controlled grazing area had significantly (P=< 0.05) higher OM content (3.5%) compared to the no-grazed, but not significant (P=< 0.05) from the controlled grazing area (3%). Grazing significantly decreased $F_{(t)}$ and HC when compared to NG. Grazing significantly (P=< 0.05) reduced cumulative infiltration. The highest cumulative infiltration was observed in no-grazed area while the lowest was in un-controlled grazing area. Also, significant results showed that Grazing reduced (HC), however no significant (P=< 0.05) differences were observed between controlled and un-controlled grazing areas (P=< 0.05). The higher HC was in no-grazed site ($0.172*10^3$ cm $s^{-1}$) while the lowest was in un-controlled grazing area ($0.034*10^3$ cm $s^{-1}$). Therefore, controlling grazing intensity is recommended in these dry areas.

**Keywords:** Grazing - Infiltration - Aggregate stability - Bulk density - Soil organic matter

## 1. Introduction

In Jordan, rangelands are usually defined as areas that receive less than 200 mm of annual rainfall (IUCN, 2015). Arid lands cover more than 90% of the country's lands. Considering the frequent droughts and overgrazing of natural vegetation; the level of rangelands degradation in Jordan is expected to be high (IUCN, 2015). Livestock overgrazing is one of the human activities that cause degradation of grassland (Yong-Zhong et al., 2005). Overgrazing has destructive effects on plant community and soils. It reduces canopy cover, destruct topsoil structure, and compact soil by trampling of animal hooves. These processes increase soil crusting, decrease soil infiltration, and increase soil susceptibility to erosion (Yong-Zhong et al., 2005). Among soil physical properties; soil compaction and bulk density have been reported to be severely affected by animal trampling (Kotzé et al., 2013). In Monogolia, Yong-Zong et al. (2005) reported that soil bulk density of grazed plots was higher than non-grazed ones. Steffens et al. (2008); Li et al., (2008) found the same results. While the literature reported by Abdel-Magid et al. (1987), George et al. (2013), Teague et al. (2011) and Tobergte et al. (1999) concluded that bulk density was not affected by grazing systems or stocking rate. Livestock grazing reduces infiltration by either loss of vegetation cover or decrease in the amount of plant cover therefore increasing bare ground surface and bulk density (McCalla et al., 1984). Wheeler et al. (2002) reported unexplained variability in the infiltration rate, where infiltration rate was significantly decreased at 5-10 cm depth and 10-15 cm depth immediately following grazing in grazed plot and then returned to pre-disturbed value within 1 year after grazing event.

Wang et al. (2012) found that decreasing grazing intensity lead to significant increase in soil organic carbon (SOC), total nitrogen (TN) and total phosphorous (TP) concentrations. Xiong et al. (2014) found that grazing exclusion for six years increased the above and below ground biomass, SOC and TN. Cui et al. (2005) showed that long-term and no grazing had no significant effect on SOC. Pei et al. (2008) found that exclusion enhanced SOC and TN accumulations. Ferreiro-Domínguez et al. (2016) reported that ungrazing enhanced (SOC) storage compared to grazing and this carbon was linked to increased soil density. Wang et al. (2014) found that carbon content in the topsoil, plant biomass, and grass diversity increased after grazing exclusion. Wang et al. (2016) showed that grazing exclusion improved plant aboveground biomass and diversity as well as SOC, TN. Tessema et al. (2011) found that light grazing sites had higher OC and P, indicating improved soil nutrient status compared with heavy grazed sites.

Grazing has destructive effect on aggregate stability (AS). Contradictory results were reported on the effects of grazing on soils (Lavado et al., 1996). For example, Beukes et al. (2003) found that there was increase in (AS) in non-selective grazing compared to the control. Vargas et al. (2009) reported that no-grazing increased soil (AS) due to presence of plant residues. Teague, et al. (2011) found that soil (AS) was higher with multi-paddock than heavy continuous (HC) grazing, but not to light continuous (LC) grazing. On the other hand, Reszkowska, et al. (2011) reported that grazing increased the tensile strength of aggregates. Kotzé et al. (2013) found that deterioration of aggregates and associated SOM in poor and moderates rangeland conditions.

Contradictory results were reported on the effects of grazing on soil porosity. Sharrow (2007) found that livestock grazing did change soil porosity; however, these effects could be quickly overturned when grazing is ceased. Conversely, Cournane, et al. (2011) reported an increase in macroporosity in light grazed areas. Huang et al. (2007) found that soil bulk density increased (BD) with the decline of soil porosity and compaction as the desertification process continued.

Grazing may change soil pH through the addition of organic matter. Mapfumo et al. (2000), Steffens et al. (2008), While Wang et al. (2012) and Li et al. (2008) found that grazing had no significant changes on soil pH in the upper 5-15 cm of soil. Tobergte and Curtis (1999) found that pH decreased in 4 years grazed plot compared with un-grazed ones. However, soil pH decreased after 9 years of very high grazing pressure. Moderately and heavily grazed pastures in Malaysia produced higher pH and electrical conductivity (EC) values compared with ungrazed sites (Ajorlo, et al., 2011). Similar results were observed by Ebrahimi, et al. (2016). Moreover, Ma et al. (2016) and Tessema et al. (2011) found that grazing slightly increased soil pH.

Conflicting results were reported on the effect of grazing on soil EC. Mapfumo et al. (2000) reported that grazing intensity had significant influence on soil EC at all depth intervals except for the upper 5 cm. Tessema, et al. (2011) and Ajorlo, et al. (2011) showed that light, moderately and heavily grazed pastures were higher in EC than the ungrazed ones. While Li et al. (2008) and Ebrahimi et al. (2016) reported no significant effect of grazing on soil EC, Li et al. (2011) found that grazing exclosure increased soil EC.

The goal of this study is to evaluate the impact of grazing on some physical, hydraulic and chemical properties of soil in three selected sites (ungrazed, moderately, and heavily grazed), at AlKhanasri station, in Jordan.

## 2. Materials and Methods

### 2.1. Experimental site and Design

The study site is located at Al-Khanasry Agricultural Station (55°NE 32°24' 22" N 36°3' 30" E) at 670m elevation above sea level, 30 km east of Irbid city. The area is characterized by dry climate with annual precipitation below 200 mm (IUCN, 2015).

The station contains three areas (0.7-1 ha each): (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing. The design of the three experimental areas closely mimics the general grazing activities in that area.

The overall area of the station is about 450 hectares, about 50-60 hectares are under controlled grazing and about 5 hectares are no-grazed. The grazing starts from January to May, two hours daily, 5 days weekly for ten years. The total number of grazing animals (sheep) is about 400 (91% females), and about 60 goats. The grazing is commenced in groups. The main soil texture in the station is loam in the surface and clay loam in the sub-surface.

In summer 2016 measurements were conducted in seven plots of different grazing intensities two no-grazed (protected), two controlled grazing and three un-controlled grazing.

In each experimental field, forty-two samples were collected along a 50 m straight line for bulk density (BD), and cation exchange capacity (CEC) determination, whereas eighty-four samples and or runs were determined for other soil properties (e.g., Infiltration, hydraulic conductivity, pH and electrical conductivity (EC). All soil samples were taken from two depths (0-20cm and 20-40 cm) and stored in a single bag. Infiltration measurements were conducted in the field using a mini-disk infiltrometer (MDI) (Decagon devices, USA) at a suction of 5 hPa (5 cm). Infiltration time was recorded at regular volume intervals from which the hydraulic conductivity was calculated according to Zhang (1997). Soil texture was determined using the hydrometer method (Gee and Bauder, 1986). Penetration resistance was measured using pentrometer (N $m^{-2}$) (Lowery and Morrison (2002). For bulk density determination; soil samples were taken at two depth intervals (0-20 and 20-40 cm) in **six** replicates from each plot using stainless-steel cylinder 100 $cm^3$ in volume (Blake and Hartge, 1986). Aggregate stability of soil samples was determined using the wet-sieving method (Kemper and Rosenau, 1986). Soil pH and electrical conductivity (EC) were measured in 1:1 extract following the methods described by (Rhoades, 1982; and McLean, 1982). Organic matter by loss on ignition (LOI) method (Nelson and Sommers, 1996), cation exchange capacity (CEC) as described by Polemio and Rhoades (1977).

### 2.2. Statistical analysis

Data were statistically examined using the complete randomized design. Means of significant factors ($P < 0.05$) were separated using Fisher's Test at $P < 0.05$.

## 3. Results and Discussion

### 3.1. Effect of Grazing on Soil Physical Properties

#### 3.1.1. Bulk Density (BD) and Penetration Resistance (PR)

The statistical analysis showed that Animal grazing significantly increased soil bulk density (BD) in both surface and subsurface layers (Figure 1). CG and UnG sites showed similar BD (P=< 0.05). And the NG site showed lowest BD, while the highest was in CG (1.47 g $cm^{-3}$). Moreover, UnG had lower BD but not significant compared to CG site (1.42 g $cm^{-3}$). This could be attributed to presence of animal manure that resulted in higher OM content. These results are consistence with Wang et al. (2012) who demonstrated that animal grazing increased the soil bulk density by reducing the total pore space in the soil. Moreover, hoof action may result in greater soil bulk density and greater soil surface compaction (Ma et al., 2016).

Pie et al. (2008) and Kotzé et al. (2013) found that higher BD in grazed site presumably resulted from soil compaction by livestock trampling, and from the decrease in belowground biomass. Grazing can significantly reduce vegetation cover, compact soil by trampling and therefore reducing soil porosity (as indicated by the higher soil bulk densities) and water infiltration. Our results are also consistent with the findings of Kölbl, et al. (2011) who reported that higher BD in highly grazing sites are most likely resulted from homogenization and compaction due to animal trampling, lower mechanical soil stability, and is further increased by lower OM content. On the other hand, Yong-Zhong et al. (2005) found that increasing the ground cover following exclusion of livestock effectively protected soil loss by wind erosion, increased OM, and extended root systems which contributed to significant decrease in BD.

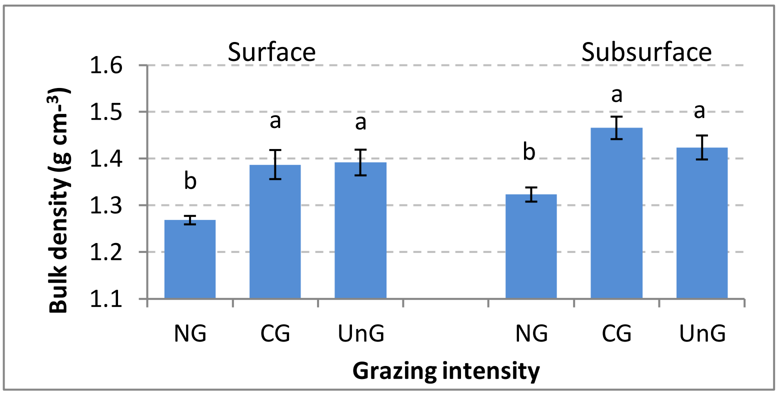


**Figure (1) Soil bulk density for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing**.
Different letters within the same sub-graph represent significant differences between treatments at $p < 0.05$. Values are averages of eight replicates of each treatment, with error bars representing standard error in y-axis.

Soil strength is frequently measured by penetration resistance (PR). Animal hooves can exert pressure up to 200 kPa, which is considerably greater than the pressure exerted on the soil surface by a tractor, which can range from 30 to 150 kPa (Proffitt et al., 1993).
Grazing increased PR, however significant effect was only observed with UnG site compared to the NG site (Figure 2). The highest PR was in UnG (524 $N/m^2$), while the lowest was observed in NG sites (366 $N/m^2$). Animal trampling was reported to be the main factor degrading topsoil structural properties by reducing water-stable aggregation (AS), infiltration rates, and increasing BD and PR, , and by reducing soil aeration by loss of air-filled macropore space (Greacen and Sands 1980; Proffitt et al., 1995; Steffens et al., 2008).
Schmalz et al. (2013) showed that PR was affected by cattle stocking rates. Their study showed increased PR values with increasing stocking rate. Chanasyk and Naeth (1995) reported significantly higher PR in heavily grazed treatments in fescue grasslands in Alberta, Canada. Moreover, Villamil et al. (2001) reported that in semi-arid temperate grasslands in Argentina, un-grazing for 30 year significantly lowered PR compared to areas under moderate or intense grazing. Such finding was also observed with Teague et al. (2011) study. They found significantly lower PR in ungrazed compared to light and heavy continuous grazing management. Thus, our results support previous findings and demonstrate that PR increases with stocking rates and warrants careful monitoring to guide management prescriptions.

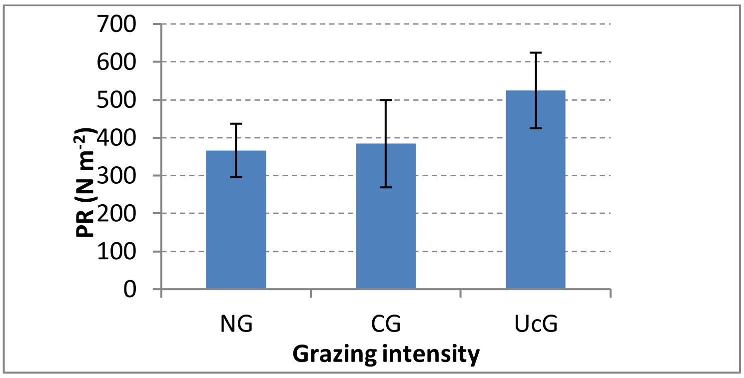


**Figure (2) Penetration resistance (PR) for surface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**
Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

### 3.1.2. Aggregate Stability (AS)

Grazing significantly increased (AS) (P=< 0.05) only in the surface layer (Figure 3). The lowest AS in surface layer was observed in NG plot (17.4%), while no significant difference (P=< 0.05) were observed between CG and UnG plots (24.6 and 24.8%), respectively (Figure 3). These results are consistence with Beukes and Cowling, (2003) who reported that grazed areas showed significantly higher AS compared to the control. They suggested that litter and dung addition with mixing and aeration of surface layers in non-selective grazed area rapidly increased soil biotic processes and resulted in the formation of stable aggregates.

In subsurface layers, higher AS value were observed in CG (42.0%) with no significant differences with UnG area (40.4%). UnG area had the lowest AS value (36.4%). Our results are in agreement with Franzluebbers and Stuedemann, (2008) who found that moderate cattle grazing had little impact on soil AS owing that to the presence of grass roots and debris at the soil surface that appears to be more important for aggregation than the presence of grazing animals.

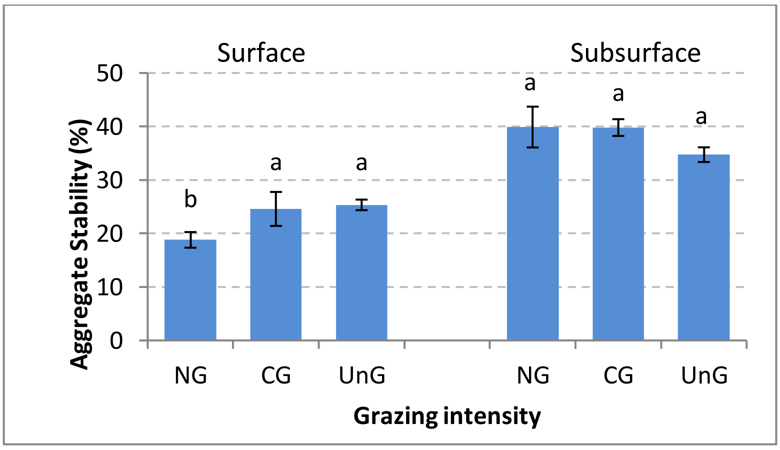


**Figure (3) Aggregate stability (AS) for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**
Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

### 3.1.3. Infiltration

Grazing significantly (P=< 0.05) reduced cumulative infiltration (Figure 4). The highest cumulative infiltration was observed in NG area while the lowest was in UnG area. The reduction in infiltration could be attributed to increased soil compaction as seen from BD values (Figure 1) and to crust formation at higher grazing rates represented by penetration resistance values. As the BD of soil increases, the penetrability of the soil will decrease, and so will the rate of infiltration of water into the soil will decrease (du Toit et al., 2009). Reduced water infiltration under grazing is generally attributed to soil compaction by trampling and sealing of the soil surface (Llacos 1962).

Trampling by livestock causes soil compaction, reduces pore size, decreases water infiltration, and increase runoff hence increases soil erodibility (Dahwa et al., 2013). This decrease could also be explained by reduced soil Macro-faune (mostly termites and ants) activity. Faunal activity has been found to be an important agent for control of soil crusting. It improves the physical properties of the soil and contributes considerably to increased infiltration in seasonally dry ecosystems (Mando et al., 1996 and de Rouw and Rajot, 2004).

Other studies (Warren et al., 1986 and Jarret and Fritton 1978) reported no significant differences between infiltration in un-grazed and moderate grazed areas. They attributed that the compression of entrapped air during infiltration which in turn reduces the hydraulic head gradient (driving force for infiltration), therefore reducing infiltration rate. Moreover, higher infiltration in light grazing was attributed to better decomposition of accumulated litter due to moderate trampling and change in drainage pore volume brought by disruption of aggregates, surface crust and remoulding resulting from animal trampling while lower infiltration rate was attributed to the development of soil crust under grazing. Compared to un-grazed site, cumulative infiltration was reduced by 60% in highly grazed and to 40% in moderately grazed sites. Similar results were reported by Gifford and Hawkins (1978) who concluded that, on the average, light/moderate grazing results in about 25% lower infiltration than on ungrazed areas. Tongway and Hindley (2004) observed higher infiltration rates and hydraulic conductivity and increased water availability inside protected areas aimed at restoration of degraded rangelands under intense grazing. The improvement of soil water in restored areas created better environment for better germination, growth, and successful regeneration of species. This in turn has significant biodiversity benefits and simultaneously sequestering C in soil and biomass. Grazing also decreases the infiltration rate by reducing vegetation cover and amount of organic matter in the topsoil, especially at high stocking rates (Mwendera et al., 1997). A decrease of organic matter content in the soil will lower macro-porosity, which reduces infiltrability (Stroosnijder, 1996).

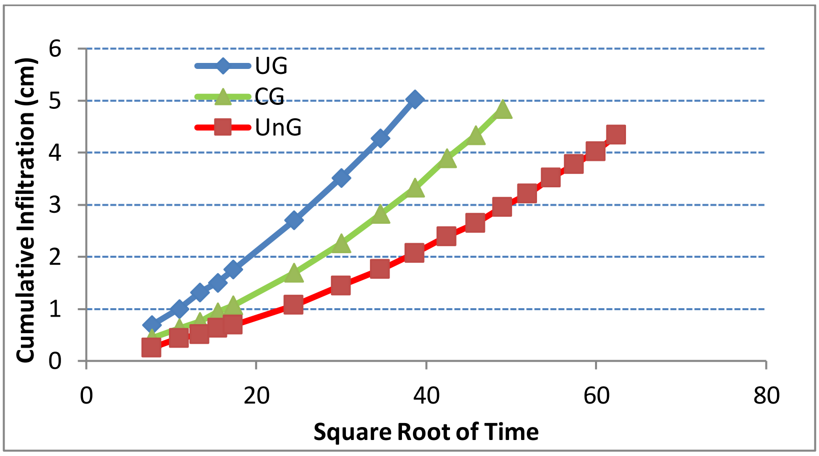


**Figure (4) Cumulative infiltration under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**

### 3.1.4. Hydraulic Conductivity (HC)

Grazing significantly reduced (HC) (Figure 5), however NG (P=< 0.05) differences were observed between CG and UnG areas (P=< 0.05). The higher HC was in NG site ($0.172*10^3$ cm $s^{-1}$) while the lowest was in UnG area ($0.034*10^3$ cm $s^{-1}$). Similar results were observed with Greenwood et al. (1998) where HC was the highest in un-grazed sites. Grazing increases soil BD and decreases HC (Burch et al., 1986; Edmond, 1974; Willatt and Pullar, 1983). Ben-Hur et al. (2009) observed greater conducting pores and lower BD values in un-grazed treatments, but also varied over time. This temporal variation has been attributed to a number of processes including: shrinkage and swelling, dispersion and slaking due to rapid wetting (Ben-Hur et al., 2009), frost heave, plant root penetration, earthworm burrowing, and management practices (Drewry, 2006).

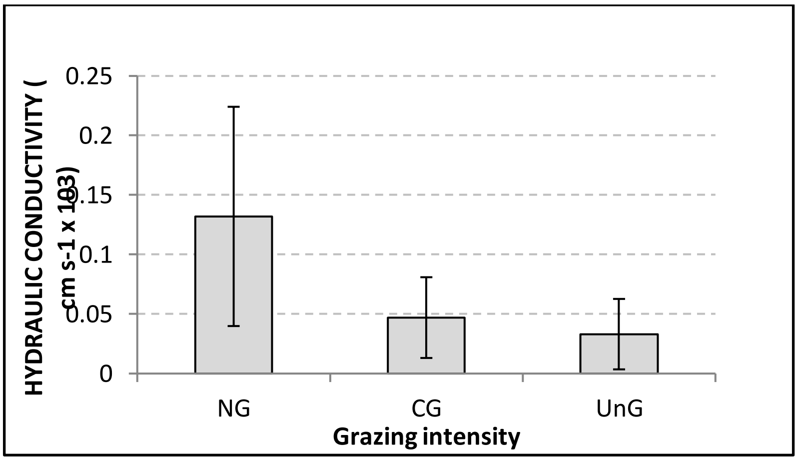


**Figure (5) Hydraulic conductivity (HC) for surface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**

Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

## 3.2. Effect of Grazing on Soil Chemical Properties

### 3.2.1. Soil Organic Matter

Grazing significantly (P=< 0.05) increased soil OM in surface layers, however in subsurface layers no consistent results were observed (Figure 6). UnG area had significantly (P=< 0.05) higher OM content (3.82%) compared to the NG (2.46%), but not significant (P=< 0.05) from the CG area (3.4%).

In the subsurface, the highest OM content was in UnG (2.94%) with no significant differences (P=< 0.05) between NG (2.4%) and CG (2.0%) areas. Studies on the effect of grazing on semiarid grasslands showed inconsistent results. For example, Milchunas and Lauenroth (1993) reported decreases in soil organic carbon (OC), while Frank et al. (1995), Derner et al. (1997), and Reeder and Schuman (2002) reported increased OC. On the other hand, Schuman et al. (1999) and Li, et al. (2008) observed no effect of grazing on OC content. The effect of grazing on soil organic C and OM is complex and hence its accumulation or storage in grazed versus non-grazed soils.

Piñeiro et al. (2010) proposed that grazing can influence soil organic C accumulation simultaneously by more than one pathway. These pathways include altering net primary production, changing total soil organic nitrogen pathway, or changing soil organic matter decomposition. They found that microbial biomass C (biologically active fraction of soil organic C) was greater in grazed than non-grazed areas in non-irrigated plots. This active fraction plays an important role in mineralization and cycling of nutrients, decomposition and formation of soil organic matter (George et al., 2013). Moreover, the effect of grazing on soil OC is weakly expressed partly due to the large fraction of highly stable humic substances present in soil that are not very responsive to grazing (Li, et al., 2008).

Xie and Wittig (2004) indicated that with the increasing depth of soil, the influence of grazing intensity on soil organic substances was found to be less significant. Short term grazing is reported to affect total carbon (TC) content in surface more than subsurface layers. However, long term grazing had significant effect on TC in grazed and unglazed areas. Moreover, higher TC in upper soil layer of grazed pastures was attributed to deposition of organic matter by cattle faeces, greater detrital inputs of grass litter into the soils, and concentration of grass roots in surface soil at 0-10 cm (Ajorlo et al., 2011). Ajorlo et al. (2011) also found that detrital plants (grass litter) into soil in grazed area was greater than the ungrazed ones, however they attributed the higher total C in the subsoil of the ungrazed pasture in long-term grazed pasture to the high grass root turnover rate.

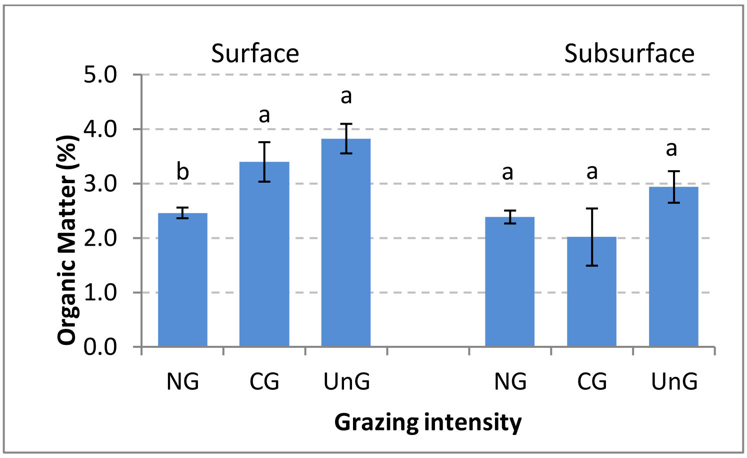


**Figure (6) Organic matter for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**
Different letters within the same sub-graph represent significant differences between treatments at $p < 0.05$. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

### 3.2.2. Soil pH

Grazing significantly (P=< 0.05) reduced soil pH in surface and subsurface layers (Figure 7). Moreover, grazing significantly (P=< 0.05) reduced soil pH in subsurface compared to surface layers. It is reported that there is a negative relationship between soil pH and carbon content (Wang et al., 2014). Our findings are in agreement with Liu et al. (2013) who reported that soil pH decreased with increased soil organic carbon (SOC) in the topsoil after grazing exclusion. Teague et al. (2011) explained the high pH level was presumably related to the ability of soil C to buffer soil reaction. Higher pH in highly grazed plots may be attributed to large amount of ammonia produced by urea hydrolysis in sheep urine and cations deposition from sheep manure (Jusoff 1988). Moreover, according to (Mapfumo et al., 2000) the addition of ammonium from the urea in animal urine in subsurface grazed area may have decreased soil pH due to release of H ions during nitrification, and therefore noticeable differences were observed compared to surface layer Westerman et al. (1985) reported that more than 50% of ammonium was lost from fresh cattle wastes through volatilization three days after deposition. Moreover, increased nitrate availability in the deeper soil layers could also cause an increase in the uptake of cations by the plant roots which could be recycled from the deeper to the surface soil layers. Overall, a constant rate of change of pH over time was assumed to take at least 15 years to affect a unit change in soil pH (Mapfumo et al., 2000).

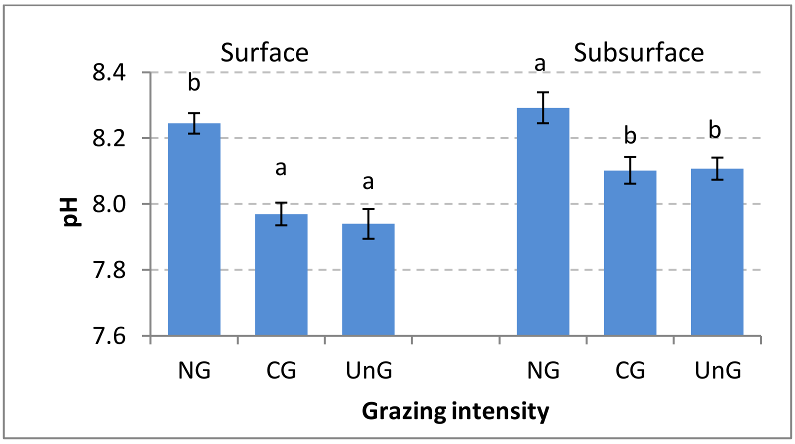


**Figure (7) Soil pH for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**
Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

### 3.2.3 Electrical Conductivity

Grazing significantly (P=< 0.05) increased soil EC in surface layers (Figure 8). The highest EC was observed in UnG area and the lowest in NG ones (Table 2). However, inconsistent results were observed in the subsurface layers. Su et al. (2006) observed similar results where EC under high grazed sites was slightly higher than medium grazed ones, but no difference was found between the two treatments. The greater increase in EC under heavy compared to medium and light grazing treatments for surface layers may be attributed to increased urine and dung loading rates as well as organic-N mineralization to produced mineral N. These processes are known to increase total solutes in soil solution which is directly related to electrical conductivity (Mapfumo et al., 2000). Chaneton and Lavado (1996) reported that continuous grazing increased salt content as a result of reduced plant and litter cover, which increased soil temperatures and evaporation rates and therefore resulted in salt buildup during dry season.

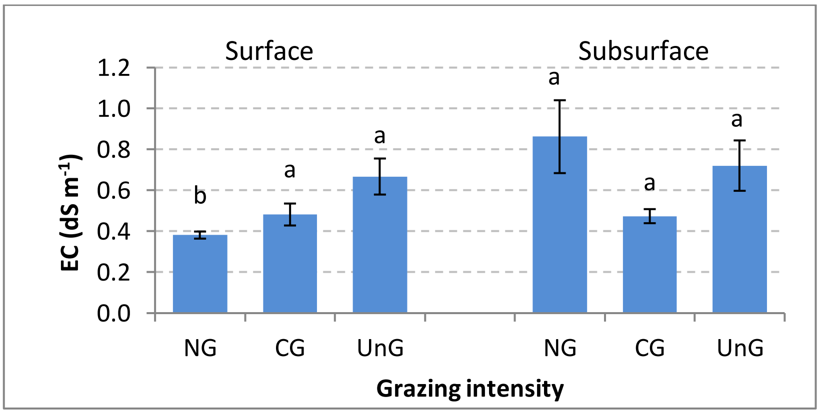


**Figure (8) Soil electrical conductivity (EC) for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**
Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

### 3.2.4 Cation Exchange Capacity (CEC)

As expected, no significant differences (P=< 0.05) were observed between treatments (Figure 9). On average, the UnG area had higher CEC value compared to other sites (NG and CG sites). This could be attributed to increased OM content in both grazed sites. The increase in OM could be attributed to deposition of organic matter by animal faces (Ajorlo et al., 2011). Similar results were reported by Teague et al. (2011) where higher carbon content was observed in grazed areas. Higher CEC values in grazed areas could be attributed to elevated levels of exchangeable cations in the surface soils might be caused by a stocking effect, resulting in a greater deposition of waste through faeces and urine, followed by subsequent decomposition and distribution throughout the soil profile (Tessema et al., 2011; Ajorlo et al., 2011).

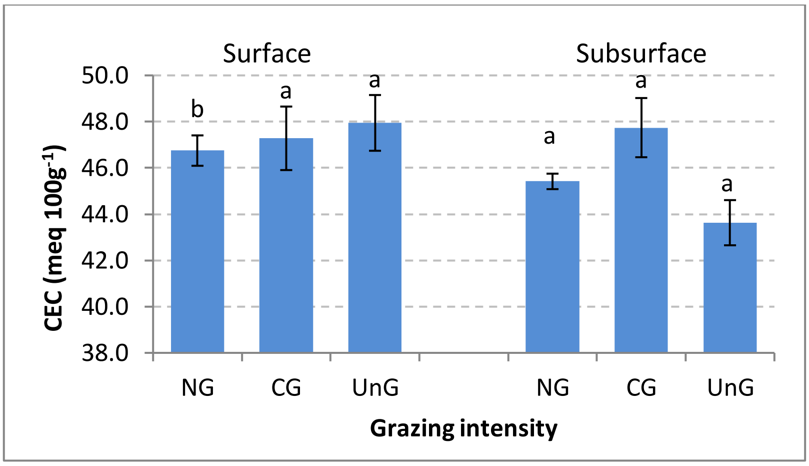


**Figure (9) Cation exchange capacity (CEC) for surface and subsurface soil, under three grazing intensities in Al Khanasri station. (NG): No-grazed, (CG): Controlled grazing, (UnG): Un controlled grazing.**

Different letters within the same sub-graph represent significant differences between treatments at p <0.05. Values are averages over six replicates of each treatment, with error bars representing standard error in y-axis.

## 4. Conclusion

Un-controlled grazing decreased water infiltration, hydraulic conductivity due to animal trampling which resulted in soil compaction, and prevention of water movement, while soil organic matter, aggregate stability were increased due addition of animal manure. This research showed that soil properties can significantly be affected by grazing intensity. Therefore, given the socio-economic aspects; it is recommended control grazing under current management and climatic conditions.

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# تأثير الرعي على خصائص التربة الفيزيائية والكيميائية

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**الملخص**

للرعي آثار مدمرة على خصائص التربة، تهدف هذه الدراسة لتحديد مدى تأثير الرعي على بعض خصائص التربة الفيزيائية والكيميائية والهيدروليكيه. تم تقييم تأثير الرعي في ثلاثة مواقع في محطة الخناصري الزراعية، المفرق، الأردن: (1) غير مرعيه أو محمية (الشاهد) (2) معتدلة الرعي، و(3) رعي جائر. تم جمع عينات التربة من كل المواقع لتحديد الكثافة الظاهرية، ثباتية مجاميع التربة، ومحتوى المادة العضوية، والايصالية الكهربائية، ودرجة الحموضة، والقدرة على التبادل الكاتيوني، وتم قيس غيض الماء والايصاليه المائية في الحقل. أظهرت نتائج الدراسة ان الرعي الجائر أدى الى زيادة معنوية في الكثافة الظاهرية، ثباتية مجاميع التربة، ومحتوى المادة العضوية وانخفاض معنوي في غيض الماء والايصاليه المائية مقارنة بالشاهد. وأشارت النتائج إلى أن الرعي المعتدل كان له تأثير أقل على خصائص التربة، ولذلك يوصى بالمراقبة والسيطرة على الرعي في هذه المناطق.

**الكلمات المفتاحية** :الرعي – التسرب – ثباتية التربة – الكثافة الظاهرية – المادة العضوية في التربة –درجة الحموضة .