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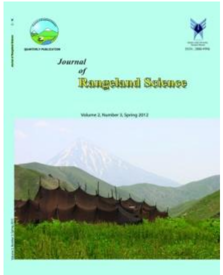

Full Length Article:

Grazing Response of Topsoil Characteristics in Temperate Rangelands of Kashmir, Himalaya

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Abstract. The superficial strata of ground have been perennially exposed to the action of natural agents such as heat, cold and water. However, grazing agent was not different from them when soils were investigated from temperate rangelands of Kashmir and caused the soil compaction, soil structure degradation and loss of soil organic C and C/N ratio. Soils from three grazing intensities were investigated for physio-chemical parameters. The results showed that soil bulk density was the lowest in Low Grazed (LG) areas and critical in Highly Grazed (HG) areas. The results revealed that C storage in 0–10 cm of soil layers was decreased linearly with the increase of stocking rates. However, total soil nitrogen content in HG is 1.26 times more than LG. Therefore, grazing is responsible for major changes in the physical and chemical properties of the topsoil which may further cause the spatial heterogeneity followed by regional ecological problems.

Key words: Soil physical properties, Overgrazing, Livestock trampling, Pasture.

Introduction

Most plants with the exception of the Epiphytes and aquatic plants send roots down into the soil no more than 1 m. The stratum most explored by roots, therefore, is up to 30-50 cm deep. Cultivable soil is that superficial part of the earth's crust which is able to sustain and provide nourishment to plants. The superficial strata of the ground have been perennially exposed to the action of natural agents such as heat, cold and water as well as the action of microorganisms- aerobics and anaerobics that bring about the gradual disintegration of the parent rock material. However, grazing one such agent is no way different from these and enables certain soluble mineral substances to accumulate so that they can be absorbed and transformed by plants during the various phases of that perpetual cycle known as the food chain. Similarly, effective factors in the growth of plants are soil physical properties. Moving animal pressures during grazing are higher as the body weight is distributed on only two or four hooves. As compactive effect of grazing livestock is shallower (Greenwood and McKenzie, 2001), the effects are only seen in the topsoil (0-10 cm). Livestock grazing has restricted water movement into and through the soil profile, especially during rainstorms (Linnartz *et al*., 1966). This effect can be attributed to both compacted soil and reduced vegetation cover. Studies have shown that cattle's grazing on the sloping pasturelands contributes to the run-off, soil erosion and loss of nutrients (McDowell *et al*., 2005). Grazing can cause a disorder to the natural chemical processes of the soil while at the same time, causing the erosion of soil. Grazing, in general, affects the ecosystem, disrupting both physical characteristics and the surrounding species population. Overgrazing can lead to a decreased forage yield. In addition, the lack of ground cover causes the top soil to be more susceptible to the erosion and increased weed invasion (Casimir and Rao, 1998; Neff *et al.*, 2005). The vegetation is bound to the soil and helps to prevent from the erosion and run off during rainfall; however, when livestock grazing takes place, it causes some shifts in the plant community structure and plant biomass usually called as ecological "Boom Bust Cycles". After 25 years of exclusion in a semiarid steppe of Inner Mongolia, soil physical and chemical properties were found significantly different from the initial values for all parameters (Steffens *et al.,* 2008). Thus, physical and chemical parameters of steppe topsoil deteriorated significantly due to heavy grazing and remained stable if grazing was reduced or excluded for five years, and recovered significantly after 25 years of grazing exclusion. Considering the rangeland degradation and the most determinant role of livestock grazing intensity on vegetation, soil destruction and erosion, it is necessary to show the destructive role of livestock intensity empirically. This study tries to explain the effects of grazing intensity on soil physico-chemical characteristics and vegetation cover and simultaneously highlights the ecological benefits of managed grazing by comparing the grazed and non-grazed soils.

Materials and Methods

Study area

Study area occupies the South Eastern part of the Kashmir Valley and is situated between 34^0 00' 00" N to 34^0 15' 35" N and 75^0 06' 00" E to 75^0 32' 29" E (Fig. 1). Total area of the catchment is 627 km^2 (62,700 Hectares). The study area reveals a varied topography due to a combined action of glaciers and rivers. It has sub Mediterranean climate with nearly 80% of annual rainfall which is concentrated in winter and spring seasons. The winter and summer months experience larger precipitation of 750 mm and 150 mm, respectively. The gradual rise from 2200 m to 3800 m from mean sea level has a great influence on the minimum and maximum temperatures. Its high floral diversity with both native and alien plants of a fair forage value has attracted both local and migratory grazers for the grazing grounds to countless cattle and sheep herds. Upper ranges of the study area are noteworthy for their large, lush meadows and other summer grazing extended right up to the permanent snow line and mainly utilized for summer grazing (June-September) by large herds of sheep, goats and horses. Alpine and Subalpine grasslands are in the central Himalaya generally developed on relatively steep slopes at elevations where the climate is too cold and severe for the tree growth. Time of snowmelt determines the growth initiation in early season. However, ecosystem diversity and sensitive response to environmental changes make it a place of concern for scholars all over the globe.

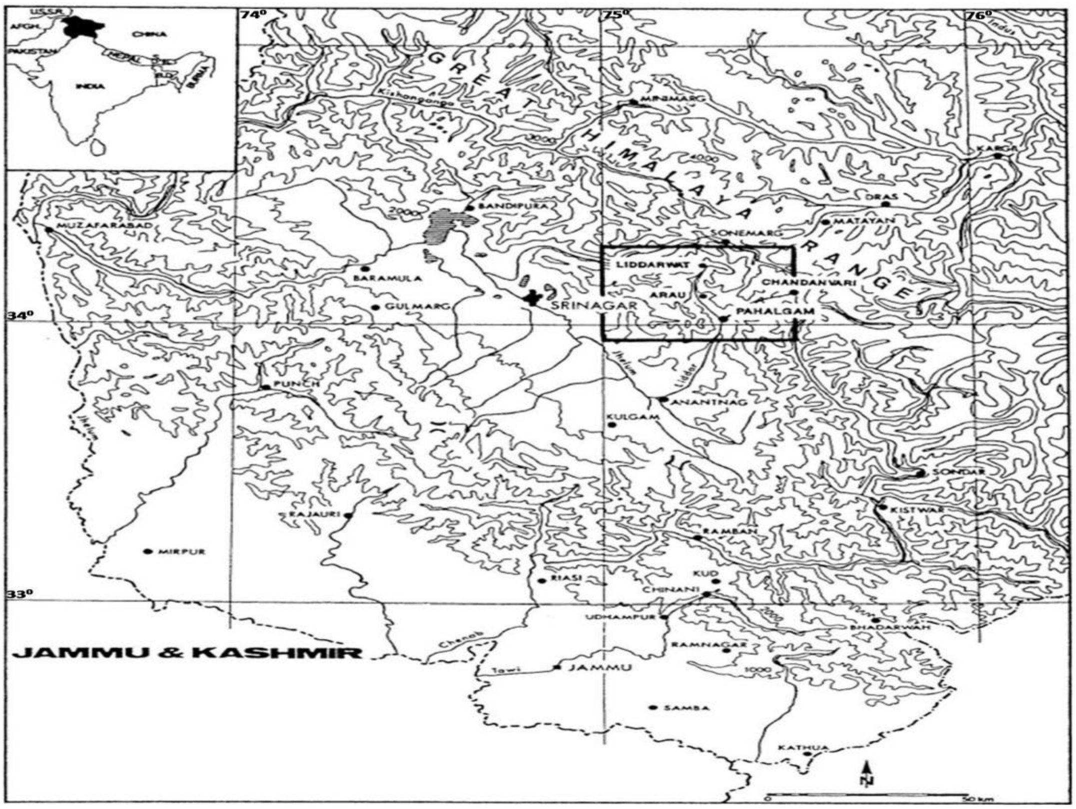

Fig. 1. Location of the selected station in Himalayas

Sampling and laboratory analyses
For implementation of this study, three regions with different grazing intensities are classified (Casimir and Rao, 1998). The experiment was conducted on three range sites with eight frequencies including:
(A): Light Grazing (LG)
(B): Medium Grazing (MG)
(C): Heavy Grazing (HG)

All sampling sites are similar in morphology (altitude, slope and climate), bed rock properties and soil texture but these regions are different in livestock grazing intensity. The samples were collected based on the main ecological and vegetation cover characteristics of study area. For the assessment of soil physical properties, soil samples were collected using a systematic random method from 0-10 cm layer of soil surface because the livestock trampling is witnessed to affect the characteristics of top soil found by (Neff *et al.*, 2005). The soil samples were air-dried and sieved to pass through 2 mm screen for the analysis of physical attributes, then through a 0.5 mm screen for analyzing the soil organic carbon and total nitrogen. Soil Bulk density was determined by a core tube method laid by Gupta (2007) for Indian soils. Soil pH and Electrical Conductivity (EC) were determined by potentiometric method in 1:5 soil–water aqueous extract. Total organic C was determined by Walkley-Black dichromate oxidation procedure (Nelson and Sommers, 1982). Total N was determined with the Kjeldahl procedure (Jackson, 1958). Hydrometric method was used for the determination of different soil samples to highlight the loss of fine fraction.

Statistical analysis

One-way analysis of variance (ANOVA) procedures were used to detect the differences in parameters examined between sites. The Least Significant Difference (LSD) was performed to determine the significance of difference in means at $p<0.05$. Pearson correlation coefficients were also used to evaluate relationships between the corresponding variables.

Results

Changes in size distribution and bulk density of soil particles

The particle size distribution showed a low amount of sand and higher amount of silt and clay in the less grazed sites as compared with the soils under free grazing (HG) (Table 1). There were significant differences ($p<0.05$) in sand and silt contents of top soil layer among all sites. The sand and silt content was the highest in HG and the lowest in LG, but there were converse orders of the clay fraction among the study sites. Soil silt and clay contents (<0.05 mm) in the top 10 cm soils under LG and MG were 31.70% and 24.96% higher than those in HG. Bulk density showed a significant difference ($p<0.05$) between Low Grazed (LG) sites and continuous free grazing ones (Table 1). Moreover, the bulk density is decreased as grazing pressure is released. Similar trend was found for the water holding capacity with no significant differences between treatments.

Table 1. Soil particles' size distribution and bulk density (Mean ±Standard Deviation)

Group	Sand 2.0-0.050mm Mean ± S.D	Silt 0.050-0.002mm Mean ± S.D	Clay <0.002mm Mean ± S.D	Bulk Density (g/cm^{-3}) Mean ± S.D	Water Holding Capacity (%) Mean ± S.D
LG	4.26 + 3.59	7.45 + 3.55	88.48 + 6.74	1.04 ± 0.24	57.54 ± 17.61
MG	5.43 +3.54	10.61 + 6.77	83.95 + 8.62	1.05 ± 0.09	58.63 ± 9.36
HG	13.74 + 11.77	19.06 +14.96	67.18 + 22.82	1.08 ± 0.20	58.71± 9.13

Changes in soil chemical properties

Soil carbon content was significantly higher in the control (LG) and Mildly Grazed (MG) treatments as compared to the Heavily Grazed (HG) samples. As grazing pressure increases, the total N content increases due to heavy load of animal urine. Of course, since total C is decreased, the C/N ratio is decreased ($p<0.05$). pH showed a significant difference ($p<0.05$) between Low Grazed (LG) and continuous free grazing sites (Table 2). The electrical conductivity is increased with the prolonged grazing ($p<0.05$). The increased urine load is also manifested itself in the increased Na and K on the exchange complex. The increase in pH is associated with the dissolution of nutrients associated with the increase in bulk density which plays a significant role in the low soil quality of grazed areas. 26% increase in N content in (HG)treatment with reference to (LG)treatment produces an appreciable amount of N-NH_3 which is the main factor for the death of edible plants and survival of weeds either poisonous or inedible. The unpredicted increase in nitrogen content of (HG) soils is because they have been sampled from the urine deposition patches which are formed by camping of huge flocks.

Table 2. Soil chemical properties under different site conditions (Mean ± Standard Deviation)

Category	TOC(mg/kg)	TKN (mg/kg)	C/N	EC (μs cm^{-1})	pH
	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D
LG	73725± 19461.1	753.7 ± 456.98	165.4 ± 160.39	304.9 ± 67.79	7.43 ± 0.23
MG	67500±19697.7	700.0 ± 200.00	102.0 ± 37.03	301.7 ± 56.61	7.44 ± 0.18
HG	65225 ± 30160.8	950.0 ± 669.75	93.4 ± 72.16	469.0 ± 139.89	7.46 ± 0.28

TOC: Total Organic Carbon, TKN: Total Kjeldhal Nitrogen, EC: Electrical Conductivit.

Correlation analysis

The correlation of different parameters as shown in Table 3 highlights the fact that pH is negatively correlated with the chemical constituents (TOC and TKN) of soil. This indicates that the increase in pH reduces the mineralized nutrients either by leaching or volatizing. Table 3 also highlights the fact that moisture content is strongly correlated with clay fraction and water holding capacity. Grazing is a prime agency for the reduction of clay content which ultimately reduces the moisture content and paves the way for the encroachment of Xerophytes like *Cirsium falconeri*, *Cirsium wallichii* and poisonous plants like *Urtica dioica* and *Sambucus wightiana*, etc.

Table 3. Pearson correlation coefficients among soil properties

	Sand	Silt	Clay	WHC	EC	pH	TOC	TKN
Sand	1							
Silt	0.587**	1						
Clay	-0.860**	-0.917**	1					
WHC	-0.292	-0.286	0.324	1				
EC	0.371	0.123	-0.263	0.013	1			
pH	0.042	0.353	-0.245	-0.334	-0.306	1		
TOC	-0.259	-0.306	0.319	0.246	-0.023	-0.203	1	
TKN	0.366	-0.217	-0.038	0.283	0.323	-0.749**	0.153	1

** Significant at the 0.01 level and * Significant at the 0.05 level.

Discussion

Impact of grazing

Different land uses and grazing managements not only cause the changes in soil structure but also have impact on physical, chemical and even biological processes (Caravaca *et al.,* 2002). The results of this study indicated that continuous free grazing induced the reduction of fine particles and coarseness of the soil, especially in the top soils (0-10cm) and resulted in a significant increase in bulk density and lower organic C concentration (Table 4). Due to browsing by sheep and cattle, most plants become shorter and vegetation disappears. Consequently, the proportion of bare ground increases. Thereafter, wind and water erosions remove most fine fraction of fertile soil (Descheemaeker *et al.,* 2006). Furthermore, animal trampling also promotes top soil erosion by wind due to the decrease of soil microphytic diversity (Golodets and Boeken, 2006). Increase of bulk density by compacting the soil (Coughenour, 1991) led to the decline of silt and clay content and increase of soil coarseness. The dominant coarse sand particle distribution, in turn, influenced the soil nutrient content. Lobe *et al.*, (2001) also pointed out that total soil N and C concentrations are associated with the silt fraction rather than sand. Additional grazing could decrease the input of organic matter and nutrients to soil due to the removal of aboveground biomass by the grazing of cattle (Huang *et al.*, 2007).

Table 4. LSD (Least Significant Differences) for the physico-chemical parameters of soils

Group	Parameter	Contrasts (p value)		
		LG v MG	LG v HG	MG v HG
Physical	Bulk density	0.096	0.032*	0.069
	Sand	0.756	0.018*	0.035*
	Silt	0.521	0.026*	0.096
	Clay	0.542	0.008*	0.032*
	Water holding capacity	0.865	0.855	0.989
Chemical	EC	0.947	0.002*	0.002*
	pH	0.950	0.013*	0.801
	Total organic carbon	0.517	0.406	0.852
	Total Nitrogen	0.826	0.425	0.312

* Significant at $p<0.05$

Ecological importance of managed grazing

The present study indicated that low grazing had significantly good effects on grassland soils. Healthy vegetation layer protects topsoil from strong wind and traps windblown fine particles and dust (Su *et al.*, 2005). This fact is attributed to higher fine particle content and lower coarse particle proportion in low grazing sites.

The changes of particle size distribution influenced bulk density (Salako *et al.*, 2006). This may also explain why bulk density difference in top soil was the most significant among the three different treatments. Soil organic C and C/N ratio showed significantly higher values in Low Grazed soils (LG). The result was similar to other researches (Wolde *et al.,* 2007). The reason for the increase in soil organic C concentration is attributed to the trapping of fertile sediments (Descheemaeker *et al.*, 2006), the increase of soil fine particles and the addition of soil organic matter from plant residue and litter (Descheemaeker *et al.*, 2006; Dezzeo *et al.*, 2004) following vegetation restoration. In addition, establishment of extensive plant root system and diversity of microbial activity (Priess *et al.*, 1999) were important for nutrient conservation. In this study, significant differences were found in pH and EC of top soil between treatments and results were similar to the results obtained by Su *et al.*, (2005). The C/N ratio was significantly higher ($p<0.05$) in Low Grazed sites (LG) than that of free grazing sites. Managed grazing could also promote the increase in soil organic C and $N\text{-}NO_3$ stocks.

Conclusion

Continuous free grazing causes the soil compaction and soil structure degradation and results in the coarseness of soil, increase of bulk density and loss of soil organic C whereas area protection or ranching leads to the improvement of soil structure, decreased bulk density, enhanced soil organic C concentration and improvement in soil fertility. Soil organic C and total $N\text{-}NO_3$ showed a significant increasing trend from High Grazed (HG) areas to Low Grazed (LG) ones. It indicated that managed grazing has a significant importance in the restoration of degraded sandy grassland and time of restoration is related to the grazing cessation period. Based on the above findings, there is a need to develop sustainable grassland ranching practices to combat the ongoing grassland degradation and improve the soil quality in the region. Application of grazing excluding is shown to be a viable method for land restoration.

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