EFFECT OF SLOPE VARIATION ON SOIL PHYSICAL PROPERTIES ON THE NORTHERN ASPECT IN SUB-TROPICAL CHIRPINE FOREST AT TRET, MURREE HILLS

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ABSTRACT

Soil physical properties such as infiltration capacity, soil moisture contents and soil bulk density were compared on varying slope of Northern Aspect in sub-tropical chirpine forest at Tret, Murree Hills. Slope was divided into three treatments i.e. gentle slope (0-30 %), medium slope (30-60 %), and steep slope (>60 %). A transect line of 100m length was laid along each treatment and replicated 5 times. On each transect line the infiltration rate (cm/hr) was determined with the help of double ring infiltrometer at mid point. Similarly for soil bulk density and soil moisture contents percent, undisturbed soil samples were collected using Galvanized iron sampler of 6cm in length and 5 cm in diameter. Results indicated that steep slope has the maximum average infiltration rate of 10.76 cm/hr, followed by medium slope 9.098 cm/hr and the lowest in gentle slope 6.63 cm/hr. The average soil bulk density of steep and gentle slope was same 2.11 gm/cm^3 while it was higher for medium slope 2.19 gm/ cm^3.The results of average soil moisture content were higher on steep slope 21.52% followed by medium 15.8% and gentle slope 11.54%.Statistical analysis (F-test) showed that infiltration rate and soil moisture content were significantly higher on steep slope followed by medium and gentle slope. The variation in bulk density on varying slopes was non significant. It was concluded that presence of good vegetation cover (50-60 percent on slopes >60%, followed by 20-30 percent on both 30-60% & <30% slopes) on steep slope was responsible for high infiltration rates. The soil was intact too on resulting in less erosion and runoff on the steep slope. The medium and gentle slopes were much degraded by over grazing, faulty land cultivation and stress of timber and fuel wood due to ease of accessibility. For soil and water conservation it is suggested that, the land should be utilized according to its capability class, grazing should be regulated through a proper system, plantation along with protection of local as well as exotic species should be carried out and soil conservation technique should be adopted if lands are to be cultivated.

INTRODUCTION

Pakistan is gifted with vast natural resources; watershed is one of these resources being misused in the past due to extensive deforestation, illegal grazing and faulty agricultural practices resulted in soil erosion affecting the water yield (Hameed, 1996). Aspect is most critical criteria for explaining/defining/interpreting the watershed characteristics in terms of vegetation and soil physical properties which need to be explored more for future sustainable integrated Watershed Management.

Aspect and its Significance

Aspect is the direction in which a valley side or slope faces. In deeply cut east-west orientated valleys, the slopes facing the equator receive more sun and are more attractive to settlement than the shaded sides of the valley.

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Aspect may be an important factor in the formation of landforms, since slopes facing away from the equator may be 6 °C colder than their opposites; estimated that gradational processes are 2-3 times as active on northward-facing slopes in the Northern Hemisphere (Beaty, 1997).

The importance of the ecological aspects has rarely been considered in North of Iran in the management of mountainous commercial. In other words, for the existing forests on different ecological aspects in a forest basin, the same management policies are currently being practiced. Investigations of the effect of aspects on the quantitative variables of managed forests help the managers to consider site condition in planning separately (Attarod, 1998).

Soil Physical properties in relation to Aspects

The watershed areas of Pakistan lie mainly in the northern part of the country. These areas are valuable assets of the country because they are responsible for the production of timber & firewood, food, water and hydroelectric power, recreation & Tourism, medicinal herbs as well as floral and faunal biodiversity. Not only the resident of the catchments are benefited from these but the impacts of these are also felt in the down population areas. Due to the lack of scientific knowledge these areas have not been managed scientifically, which resulted in flooding in down stream areas causes huge losses. The erosion of productive land resulted in silting up of hydroelectric power producing dams caused decrease in per hectare production and electricity generation (Khan, 2006).The research was carried out in Brazil to correlate the environmental variables i.e. the substrate (soil and topography) and the distribution of tree species. The results showed that differences in soil fertility and texture (related to the bedrocks) and the soil water regime (related to both soil texture and topography) were probably the chief factors determining the distribution of tree species in the forest (Goodell, 2005).Infiltration mainly depends upon the physical characteristics of the soil and it requires special attention for the purpose of accurately estimating the amount of runoff which results from the precipitation (Imran, 2008).

Previous studies analyzed the variation in soil physical properties on various aspects but no body has yet explored these variations on different slopes within an aspect which is an advance step to these researches. So the present study was designed for watershed area of Tret in Tehsil Murree of district Rawalpindi with the following objectives.

1. To find out the difference in infiltration capacity on varying slopes of Northern Aspect.

2. To find out the difference in moisture contents on varying slopes of Northern Aspect.

3. To find out the difference in soil bulk density on varying slopes of Northern Aspect.

METHOD AND MATERIAL

Description of the area

Murree is situated about 65 km from the twin cities Islamabad and Rawalplindi, approximately between 33° to 34° north latitude and 72° 42' to 73° 30' east longitude.Tret is one of the major union councils. The area has a complex geological history of organic disturbances and erosion and depositional cycles, which have resulted in the evaluation of the three major landforms: The mountains, loess plains and gravelly hills. The climate of the area is not uniform, as these are large climatic variations mainly because of altitudinal differences. The area receives major part of the rainfall during monsoon i.e. from June to middle of September (Rahim, 2000).Three ecological zones/vegetation zones prevailed in the area are, Kail zone, Chir zone and Scrub zone (Rahim, 2000).

Primary data

The primary data was collected in field regarding Infiltration rates (cm/hr), Soil bulk density (gm/cm^3) &Moisture contents percentage. The slope on Northern Aspect was divided into three categories as follows.

0 to 30% (Gentle Slope), 30 to 60% (Medium Slope) & > 60% (Steep Slope)

At each slope category a transact line of 100 meters was laid after reconnaissance of the area. Each treatment was replicated 5 times.

Infiltration rate

Along the transect line of 100 meters infiltration rate were measured at the mid point of each transect line. The inner ring was driven in the soil at selected points followed by the outer ring using hammer and crowbar (for least soil disturbance). In the inner ring known quantity of water was added. The readings were noted for each point during the first 5 minutes period in interval of 1 minute. Afterward the reading was recorded at interval of 5, and 10 minutes 1 hour.

Soil Bulk Density

Along the transect line of 100 meters soil samples were taken at the mid point of each transect line. Soil samples were taken from 15 cm depth down to surface soil. The litter and humus, if present, were removed prior to taking samples. A galvanized iron sampler of 06 cm length was penetrated into the soil to the depth that its upper surface became leveled with upper surface of the mineral soil. The soil sampler was dug out and the extra soil, roots etc were trimmed off with the help of sharp knife so that top and lower end of the core became leveled to edges of the sampler without disturbing the soil inside the sampler. These soil samples were put in plastic bag which was tightly closed and labeled. Its fresh weight was taken with spring balance. The samples was brought to PFI, laboratory. The samples were subjected to oven drying at 105 ^{0}C until the weight become constant. The oven dried soil samples were taken out of the oven and were allowed to cool for about 1 to 2 hours. Then the cooled samples were weighted for oven dry weight.

The bulk density of the soil samples was calculated with the help of following formula.

$$\text{Soil bulk density} = \frac{\text{Mass of oven dry soil(gm)}}{\text{Volume of soil core(cm square)}}$$

Soil moisture content

Since fresh and oven dry weights of soil samples were already measured so moisture content percentage was determined by using the following formula.

$$\text{Moisture\%} = \frac{\text{Fresh weight} - \text{oven dry weight}}{\text{Oven dry weight}} \times 100$$

Statistical Design

RCBD design with three treatments i.e. gentle (0-30 %), medium (30-60 %) and steep (>60 %) slopes and five replications was used to analyze the data.

RESULT AND DISCUSSION

Infiltration Capacity

(0 -30%) slope

Mean infiltration rates for first 5 minutes, 30 minutes and 1 hour were 12.12 cm/hr, 7.8 cm/hr and 6.6 cm/hr, respectively.

(30 -60%) slope

Mean infiltration rates for first 5 minutes, 30 minutes and 1 hour were 15.7 cm/hr, 10.9 cm/hr and 9.08 cm/hr respectively.

(> 60%) slope

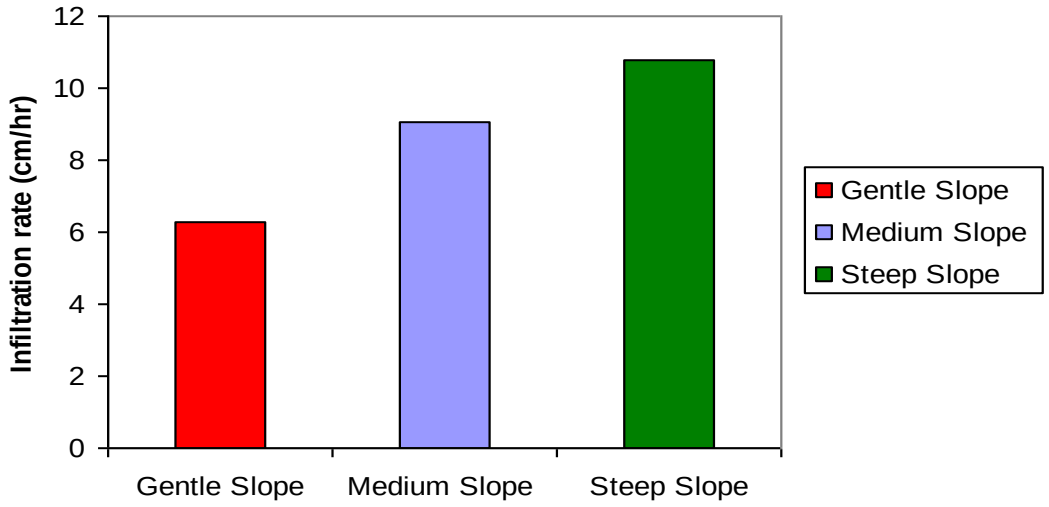
Mean infiltration rate for first 5 minutes, 30 minutes and 1 hour were 17.52 cm/hr, 12.97 cm/hr and 10.76 cm/hr respectively.

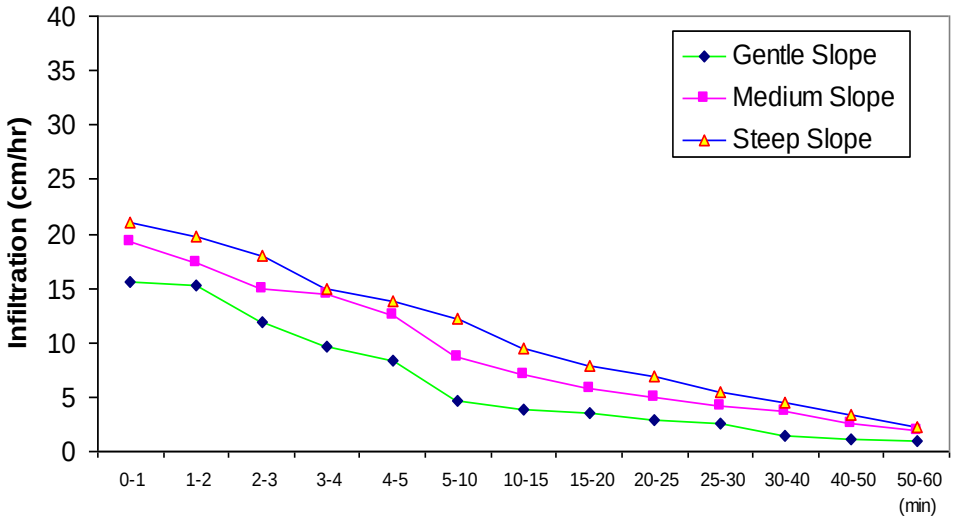
Statistical Analysis

The statistical analysis of the data for infiltration rate was carried out, using F-test probability level of 95% showed that there was no significant difference for infiltration rate between replications; the infiltration was significantly higher on steep slope as compared to gentle slope while the medium slope was in between steep slope and gentle slope.

Comparison of infiltration rate at different slopes of Northern Aspect

S.No	Interval (minutes)	Infiltration rate cm/hr		
		0-30%	30-60%	More than 60%
1	0-1	15.6	19.2	21
2	1-2	15.24	17.4	19.8
3	2-3	11.88	15	18
4	3-4	9.6	14.4	15
5	4-5	8.28	12.6	13.8
6	5-10	4.65	8.712	12.21
7	10-15	3.84	7.104	9.528
8	15-20	3.504	5.856	7.92
9	20-25	2.88	4.92	6.98
10	25-30	2.5	4.2	5.45
11	30-40	1.44	3.708	4.52
12	40-50	1.09	2.56	3.42
13	50-60	0.91	1.98	2.28
	Means	81.38	117.68	139.92



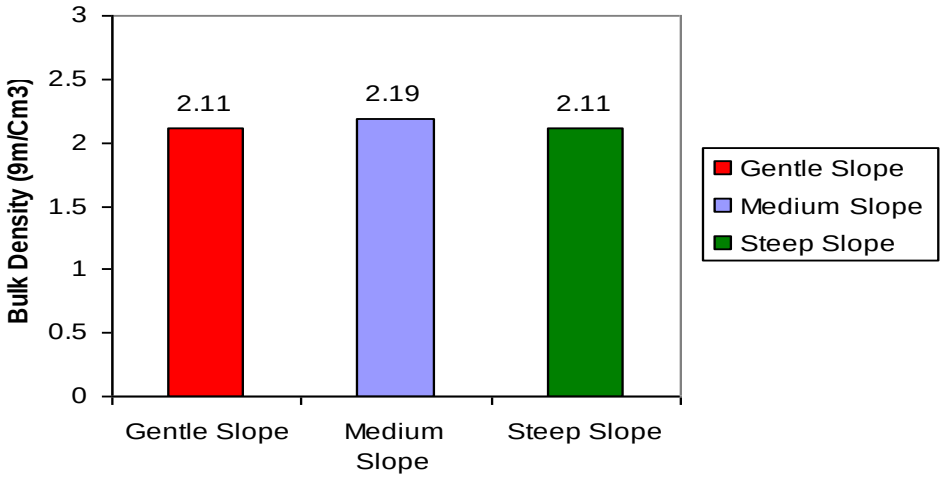


Soil Bulk density

(0 -30%) slope Average soil bulk density was 2.11 gm/cm^3
(30 -60%) slope Average soil bulk density was 2.19 gm/cm^3
(> 60%) slope Average soil bulk density was 2.11 gm/cm^3

Comparison of bulk density on different slope of Northern Aspect

Slope%	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Average
0-30	2.18	2.19	1.99	2.25	1.973	2.11
30-60	2.18	2.05	2.02	2.24	2.24	2.19
More then 60	2.12	2.33	2.04	1.98	2.10	2.11



Statistical Analysis

The statistical analysis of the data for bulk density was carried out, using F-test probability level of 95% showed that there difference for bulk density between replication was significant while difference for bulk density between the treatments was insignificant.

Soil Moisture Contents percentage

(0 -30%) slope

Average soil moisture content was 11.54%

(30 -60%) slope

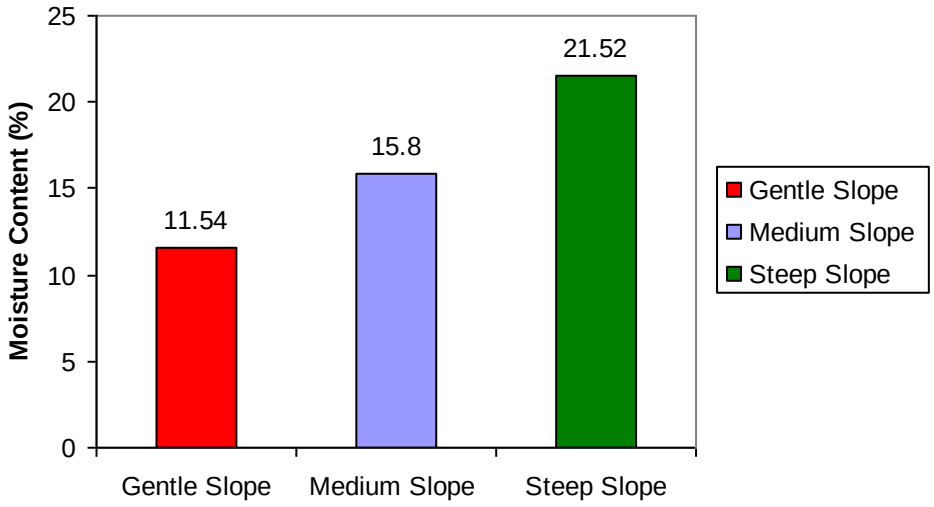
Average soil moisture content was 15.8%

(> 60%) slope

Average soil moisture content was 21.52%

Comparison of Soil Moisture Content on different slope of Northern Aspects.

Slope%	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Average
0-30	11.29	9.90	10.6	14.5	11.42	11.54
30-60	16.12	16.02	15.2	16.9	14.85	15.8
More then 60	19.8	22.6	23.6	19.8	21.81	21.52



Statistical Analysis

The statistical analysis of the data for soil moisture content was carried out using F-test probability level of 95% showed that there was no significant difference in the replication while average soil moisture content in steep slope was significantly higher then the medium slope and lowest in gentle slope.

DISCUSSION

Infiltration Capacity

Generally it is considered that more runoff is generated on steep slopes but here the infiltration capacity was significantly higher on steep slope due to good vegetation cover. High amount of leaf litter and humus had improved the soil condition. Soil was more porous, less compacted, more granular, having more water holding capacity. Soil was also stabilized by the network of roots resulting in less erosion. The grazing pressure was less on steep slope due to less accessibility resulting in more vegetation cover. The infiltration rate was significantly lower on gentle slopes due to over grazing, absence of vegetation and less porous soil due to compactness caused by grazing animals. The microbial activities were lower on gentle and medium slope as compared to the steep slope.

Soil bulk density

There was no significant difference in soil bulk density. There was little variation in bulk density among the replication due to the changes in the soil composition from place to place within the same slope. This was considered to be natural and continuous trend in all the replication.

Soil moisture content percentage

The soil moisture content percent was significantly higher in steep slope due to good infiltration rate, vegetation cover and soil composition. Large amount of humus and leaf litter provides good soil condition, more porosity, more organic matter, greater water holding capacity, more root penetration and hence more water entry. The soil moisture content percent was lower on gentle slope due to human disturbance, cutting of vegetation, encroachment for cultivation, soil compaction and high grazing pressure.

The above discussed results are consistent with the research done in different parts of the world like Auten (1933),Lei SA, (2000) , Bari and Murray (2003) ,F.R. Fiedier and McCrinle (2003) & Stone D.M. *et al,* (2006) concluded that the impact of forest management operation have significantly changed the soil physical properties, infiltration rate, productivity by altering the root growth. Root system and vegetation play an important role in the determination of infiltration rate, moisture content and bulk density.

RECOMMENDATIONS

To improve the soil physical properties such as infiltration capacity, soil bulk

density and soil moisture content on Northern Aspect following recommendations are made.

1. Indigenous as well as suitable exotic tree species should be planted and protected from grazing
2. Clearance of land for cultivation should be avoided. If cultivation is unavoidable then proper soil conservation techniques and agricultural practices should be applied.
3. Grazing should be regulated uniformly to utilize the area evenly and to keep soil and vegetation in good balance.
4. Grazing pressure should be shared by steep slopes too.
5. The area should be grazed according to the carrying capacity.
6. Planting must be coupled with reduced flood and erosion hazards.
7. Certain leguminous plants must be introduced to improve the soil fertility and binding of soil particles.

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