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Dynamics of physico -chemical properties of soil in response to hilly aspects in community forest, Rampur Palpa

Abstract

This research was objectively conducted to assess physico-chemical properties of soil among aspects. Total 64 soil samples were collected from 0 to 10 and 10-20 cm depths from North East, South East, North West and South West aspects. The physical and chemical properties of soil were analyzed in the lab. Average moisture content was found highest at North East aspect (39.46±1.11%) at 0-10 cm depth and 37.52±0.96 % at the depth of 10-20 cm. Nitrogen content was the highest 0.378±0.03% at 0-10 cm depth and 0.362±0.04 % at 10-20 cm depth in North East aspect. The amount of Potassium in the forest was found highest at North East aspect with the mean ±SE value of 523.76±75 kg/ha at 0-10 cm depth and 418.92±28.09 kg/ha at 10-20 cm depth. Phosphorus content was found to be highest again at North East aspect which has the mean±SE value of 28.202±2.22 kg/ha at 0-10 cm depth and 25.89±2.51 kg/ha at 10-20 cm depth, Similarly, organic carbon content was found highest again at North East aspect with mean±SE value of 2.18±0.06 % at 0-10 cm depth and 2.031±0.05 % at 10-20 cm depth. Elucidating pH content, the highest value was found at North West aspect with mean value of 6.32±0.19 at 0-10 cm depth and 6.02±0.21 at 10-20 cm depth respectively. Value of C:N at North Eastern aspect was recorded 5.80 at 0-10 cm depth and 5.55 at 10-20 cm depth. The study will be useful for researcher for the further work in soil science.

Keywords: organic carbon, physicochemical properties, topographic aspect

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Introduction

Soil quality has been defined as "the capacity of specific kind of soil to function, within natural and managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.[1] Thus, it would appear to be an ideal indicator of sustainable land management as it helps to assess the overall soil condition and response to management, or resilience towards natural and anthropogenic forces.[2] Soil quality and function are interrelated concepts that represent the range of soil properties and their associated ecological processes.[3] Soil is an important component of forest and woodland ecosystems because it aids in the regulation of important ecological processes like nutrient intake, decomposition, and water availability.[4]

Soil offers the anchoring, water, and nutrients to trees. As leaves and other vegetation die and disintegrate, trees, as well as other plants and vegetation, play a vital role in the production of new soil.[5] The topographic aspect, being a vital factor, impacts the structure, distribution and diversity of wild flora and the dynamics of carbon, nitrogen, and other nutrients.[6] The topographic aspect directly or indirectly influences abiotic and biotic factors, thereby contributing to the spatial variability of vegetation cover and soil conditions.[7] Spatial variation of soil properties is significantly influenced by numerous environmental factors such as landscape features, including position, topography, slope gradient and aspect, parent material, climate and vegetation.[8] The availability of water differs significantly depending on the aspect and slope angle. As a result, the soil's nutritional level is affected because plants absorb certain nutrients and return them to the soil.[9]

Variation in topographic aspect is one of the important factors that affect the soil physical and chemical properties. It is very common North East aspect is rich in fertility than other aspect. However, the study regarding the effect of topographic aspects on physico-chemical properties of soil are limitedly studied in Nepal. Thus, this research is essential.

Materials and method

A community forest was selected namely Ramchhe Community Forest, having 97.07 ha area. The reason why this particular forest was selected was because of availability of all four aspects distinctively which served the required purpose of the study. Selected community forest is situated at 27° 51' 80" N and 83° 54' 24" E. The mean annual temperature recorded is 15□C to 39 □C and the rainfall. The dominant species in the forest have been *Shorea robusta, Schima wallichii, Senegelia catechu, Dalbergia sissoo, Phyllanthus emblica, Rauvolfia serpentia* and *Castonopsis indica* (Figure 1).

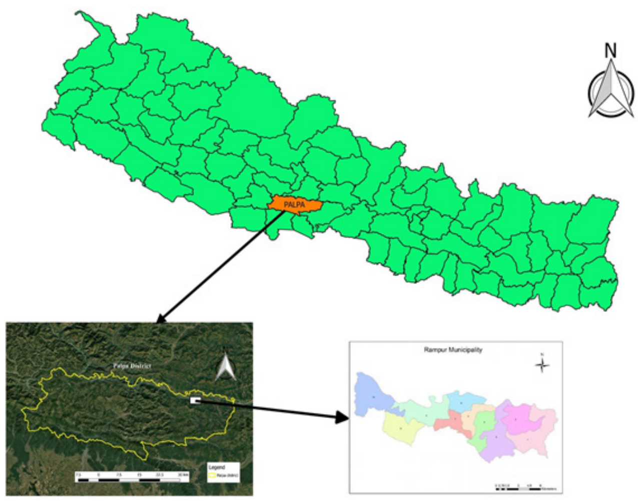

Figure 1 GIS map of study area.

Sampling design and data collection

The total forest area was divided in four main strata (North East, North West, South East and South West) according to forest aspect. For the purpose of collecting the soil sample, stratified random sampling method was applied. The randomized block design of size 10×10 m was laid upon. The soil samples at the depth 0- 10 cm and 10-20 cm were collected at 8 different spots from all the topographic aspects (North East, North West, South East and South West) by using soil Corel and shovel. The aspects were determined with the help of a GPS receiver and drainage patterns. A total of 64 soil samples were placed in labeled sample bag and the fresh weight of sample was taken in the field with the help of weighted machine. After that the collected samples were fetched to the laboratory to examine the properties. The collected soil Samples were oven dried at 80 □C in the laboratory until they reached a constant weight to estimate soil bulk density.

Lab analysis*:* The soil bulk density was calculated from the soil samples of 3 stratums (0-10 and 10-20 cm) using following formula as citated in MFSC 2071[10]:

$$Soil\ bulk\ density = \frac{oven\,dried\,weight\,of\,the\,soil}{volume\,of\,the\,soil\,in\,the\,soilcorer}$$

Oven dried weight of soil was obtained from drying the soil sample in hot air oven at

80 ˚C for 48 hours.

Volume of soil corer (cm^3) = $\pi r^2 * h$

Where, π = 3.14,

r = radius of inside diameter of ring/core = 3.5 cm and

h = height of soil corer = 10 cm

So, the volume of soil core = 3.14*(3.5)2*10 = 384.65 cm^3 = 385 cm^3

Potassium was analyzed using Flame photometric method, Nitrogen was analyzed using Kjeldahl method[11] and Phosphorus was analyzed applying Olsen's and Somers method.[12] Similarly, Walkley and Black method was used for Carbon content and pH meter for soil pH.

Statistical analysis: Statistically, following methods were performed to compare the physical and chemical properties of soil;

i. Shapiro-Wilk Test and Kolmogorov–Smirnov (n>50) was performed to examine whether the data were normal or not normal.[13]

ii. All the data performed normal character, so One-way ANOVA and Post hoc test (Tukey's b) was applied.[14]

Results and discussion

Physical properties in different aspects: The Physical properties examined were pH and Bulk Density and the data are expressed in the form of Mean± Standard Error.

The average Moisture content was found highest at North East aspect (39.46±1.11%) at 0-10 cm depth and 37.52±0.96 % at the depth of 10-20 cm. There was the lowest moisture was found at the South West aspect which was 20.87±0.65% at 0-10 cm depth and 20.13±0.80 % at 10-20 cm depth. A study carried out by Gautam et al in moist tropical forest of Sunsari found that the Bulk Density increased with increasing depth.[15] The results in the study also showed the similar patterns.

The Bulk Density was highest at South West aspect with 1.41±0.00 gm/cc at 0-10 cm depth and 1.43±0.00146 gm/cc at 10-20 cm depth. But this value was lowest at North East aspect with 1.18±0.01 gm/cc at 0-10 cm depth and 1.20±0.01 gm/cc at 10-20 cm depth.

It is very common that, the physical properties of soil are rich in North East aspect.[16] The reason behind this may, the North aspect is generally moist. However, the bulk density is affected by the ariation in the soil so it was highest in South West aspect[17] (Table 1).

Chemical properties of soil in different aspects: The chemical properties examined were N, P, K, Organic Matter, Organic Carbon and pH. The data obtained are expressed in the form of Mean± Standard Error. Nitrogen content was the highest 0.378±0.03% at 0-10 cm depth and 0.362±0.04 % at 10-20 cm depth in North East aspect, but the lowest value of this was found at South west aspect with 0.243±0.02 % at 0-10 cm depth and 0.229±0.03 % at 10-20 cm depth. Nitrogen is playing a consequential role in different biochemical and physiological functions of plant.[18] James O. Klemmedoson, 2009 found in his study that Nitrogen content was slightly greater in Northern aspect as compared to Southern aspect.[19] The findings supported this study as well.

The amount of Potassium in the forest was found highest at North East aspect with the mean ±SE value of 523.76±75 kg/ha at 0-10 cm depth and 418.92±28.09 kg/ha at 10-20 cm depth. However, the lowest mean±SE of this was 299.58±44 and 284.04±34.51 kg/ha at 0-10 and 10-20 cm depth respectively at South Western aspect. Reduction of plant available potassium in soil results in a number of negative effects, including stopping optimum utilization of applied nitrogen and phosphorus fertilizers.[20,21] Potassium is one of the determining factors in assessing the overall health of the plant.[22] A study carried out by Schmidt et al at mountainous watershed in Nepal found the available Nitrogen, Phosphorus and carbon content were found in higher amount in Northern aspect and lower in the southern aspect.[23] The reason behind this was because high moisture content favour the microbial action in soil.[24]

Phosphorus content was found to be highest at North East aspect having mean±SE value of 28.202±2.22 and 25.89±2.51 kg/ha at 0-10 cm and 10-20 cm depths respectively this was in serially North West, South Eastern and lowest at South West aspect. A study carried out by Ayed Mohhammed at Hebron City concluded that the Phosphorus content was found slightly higher at north aspect as compared to the south aspect, which supported the findings of this study.[25]

Similar pattern was of the organic carbon as well, the highest mean±SE value with 2.18±0.06 and 2.031±0.05 % at 0-10 and 10-20 cm depth at North East aspect but lowest at South Western aspect with value of 1.36±0.04 and 1.19±0.04 % at 0-10 and 10-20 cm depth.

Another important chemical properties of soil is pH, it was the highest value at North West aspect having Mean±SE with 6.32±0.19 and 6.02±0.21 at 0-10 and 10-20 cm depth respectively, The lowest value of pH at South West aspect with 5.87±0.18 and 5.7±0.17 at 0-10 and 10-20 cm depth respectively (Table 2).

The soil is generally more fertile in North East among the other aspect in hilly region because of more microbial activity.[26] The more moist soil can favour the microbe to be active and soil is more fertile in North East aspect.[27,28]

Carbon to Nitrogen ratio among aspects (C:N) in different aspects: The value of C:N at North Eastern aspect was recorded 5.80 at 0-10 cm depth and 5.55 at 10-20 cm depth. Similarly, at North west aspect the value was calculated to be 6.82 at 0-10 cm depth and 6.70 at 10-20 cm depth. South western aspect had the C:N ratio of 5.61 at 0-10 cm depth and 5.21 at 10-20 cm depth. The SOC and TN both were found be to be decreasing with increasing depths in all the aspects. The study carried out in Kankali Kafle at Kankali Forest concluded that the C:N ratio was found to be increasing with increasing depth.[29] The increase in C:N ratio with depth might have been caused due to variation in sample collection techniques and the depths from which the sample was collected[30] (Table 3).

Table 1 Physical properties of soil among different aspects

Aspect		0 to 10 cm depth				10 to 20 cm depth			
		Mean±S.E.	Max.	Min.	S.D.	Mean±S.E.	Max.	Min.	S.D.
North East	Moisture (%)	39.46±1.11	44	35.34	3.15	37.52±0.96	41.23	34.12	2.74
	Bulk Density (gm/cc)	1.18±0.01	1.23	1.11	0.03	1.20±0.01	1.24	1.14	0.03
North West	Moisture (%)	35.83±0.73	38.4	32.04	2.06	34.63±0.67	36.5	31.5	1.89
	Bulk Density (gm/cc)	1.23±0.00	1.26	1.22	0.01	1.25±0.00	1.28	1.23	0.01
South East	Moisture (%)	29.64±1.18	35	24	3.33	29±1.48	35	23	4.2
	Bulk Density (gm/cc)	1.25±0.06	1.65	1.1	0.18	1.26±0.06	1.67	1.12	0.18
South West	Moisture (%)	20.87±0.65	23.5	18.05	1.84	20.13±0.80	24.5	17	2.26
	Bulk Density (gm/cc)	1.41±0.00	1.45	1.4	0.01	1.43±0.00146	1.46	1.41	0.01

Table 2 Chemical properties of soil among different aspects

Aspect	Parameters	0 to 10 cm depth				10 to 20 cm depth			
		Mean±SE	Max.	Min.	S.D	Mean±SE	Max.	Min.	S.D.
North East	N%	0.378±0.03	0.521	0.223	0.11	0.362±0.04	0.501	0.208	0.12
	P (kg/ha)	28.202±2.22	35.06	18.15	6.285	25.89±2.51	38.7	15.78	7.108
	K kg/ha	523.76±75	951.522	323.07	214.22	418.92±28.09	526.23	324.26	79.45
	OM	3.77±0.10	4.31	3.41	0.301	3.465±0.10	3.72	2.87	0.283
	OC	2.18±0.06	2.5	1.98	0.174	2.031±0.05	2.16	1.67	0.163
	pH	6.2±0.13	6.6	5.5	0.39	6.0±0.13	6.4	5.4	0.37
North West	N%	0.284±0.02	0.364	0.116	0.07	0.266±0.01	0.31	0.18	0.04
	P kg/ha	21.90±1.61	28.125	16.01	4.574	19.69±1.46	25.08	12.01	4.135

Table 3 C:N ratio of soil among different aspects

Aspects	Soil depth cm	Total Nitrogen (ton/ha)	Total SOC (ton/ha)	C:N ratio
North East	0-10	4.48	26.01	5.80
	10-20	4.36	24.23	5.55
North West	0-10	3.51	23.99	6.82
	10-20	3.34	22.41	6.70
South East	0-10	3.14	19.47	6.20
	10-20	2.87	17.45	6.08
South West	0-10	3.45	19.37	5.61
	10-20	3.28	17.10	5.21

Statistical comparison of different parameters among aspects: One way ANOVA showed that there was significant difference in mean value of Nitrogen content at the depth of 0-10 cm among different aspects (P= 0.010) which is less than 0.05. Nitrogen content was significantly different at the depth of 10-20 cm as well as the value of P was 0.027 (P=0.027) which is less than 0.05. The one way showed that there was a significant difference in the mean value of Phosphorus content at the depth of 0-10cm as the value of p was less than 0.05 (P=0.00). The mean value of Phosphorus content at the depth of 10-20 cm was also significantly different among different aspects as P was less than 0.05, (P=0.00). Similarly, the one-way ANOVA again showed that there was not a significant difference among the mean value of Potassium among different aspects as the value of P at the depth 0-10cm and 10-20 cm were P= 0.056 and P= 0.216 respectively. 4.4.2 Comparison of Moisture Content, Bulk Density, OC and pH One way ANOVA showed that there was a significant difference in the mean value of Moisture content among different aspects at the depth of 0-10cm and 10-20cm as the values of p were less that 0.05 which were (P=0.00) and (P=0.00) respectively at those depths. One way ANOVA again showed that there was a significant difference in the mean value of organic carbon content among 4 aspects at the depths of 0-10 cm and 10-20 cm as the values 29 of P were found less than 0.05, which were (P=0.00) and (P=0.00) at both the depth of 0-10 cm and 10-20 cm respectively. One Way ANOVA showed that the mean value of pH among different aspects were not significantly different at the depth of 0-10 cm and 10-20 cm both as the values of pH were more than 0.05, it was (P=0.226) at 0-10 cm and (P=0.226) at 10-20 cm depth. Similarly, the one-way ANOVA showed that there was a significant difference between the values of bulk Density among different aspects at the depth of 0-10 cm depth as the value of p was less than 0.05, (P=0.00), the mean vale of Bulk density among different aspects at 10-20 cm depths were also found to be significantly different as the value of p was less than 0.05, which was (P=0.00).

Table 4 compares the physico-chemical parameters of soil among topographic aspects with one way ANOVA and Tukey B. Subset 1 in the table represents North East aspect, subset 2 represents South East aspect, subset 3 represents South East aspects and subset 4 represents South West aspect (Table 4).

Table 4 Statistical test of soil parameters among aspects

Parameters	Applied test	Values
Nitrogen	One Way ANOVA	P=0.01
	Tukey B	Subset (1,4,3)
		Subset (2)
Phosphorus	One Way ANOVA	P=0.00
	Tukey B	Subset (4)
		Subset (3,2)
		Subset (1)
Potassium	One Way ANOVA	P=0.056
Ph	One Way ANOVA	P=0.226
Bulk density	ANOVA	P=0.00
	Tukey B	Subset (1,2,3)
		Subset (4)
Moisture	One Way ANOVA	P=0.00
	Tukey B	Subset (1)
		Subset (2)
		Subset (3)
		Subset (4)
Organic carbon	One Way ANOVA	P=0.00
	Tukey B	Subset (1)
		Subset (2)
		Subset (3)
		Subset (4)

Conclusion

Putting all the research work done on the field and laboratory together, we reached on a conclusion that the highest amount of Soil Nutrients (N, P and K) was found in the North East aspect, followed by North West aspect, and then at South West aspect and the least amount of NPK was observed at Southern west aspect. The nutrients were found to be decreasing with increasing depth. Soil Organic carbon and organic matter were also found highest at North east aspect, which was followed by North west aspect, then at South Eastern aspect and the least was observed at South western aspect. Moisture content was also found in the order of NE, NW, SE and SW aspects respectively. Bulk Density though, showed a slight variation than other parameters, was highest at SW aspect, followed by SE, and then at NW and the least was at NE. The forest condition was found poor at all aspects, in comparison, North Eastern aspect had a slight better situation, and was followed by NW, SE, and SW aspects in that order.

This research will provide the basic information about the variation in soul physical and chemical properties in the forest. In addition, other parameters like Calcium, Magnesium and Sulfur in forest soil and factors affecting the soil physical and chemical properties will be essential issues for further study.

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Conflicts of interests

Authors declares there are no conflicts of interest.

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