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Research Article

Effects of Edaphic (Soil) Factors on Plant Distribution in Chameli Community Forest, Bhaktapur, Nepal

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Abstract

Horizontal (east, centre, west) and vertical (bottom, middle and top) distribution study of plants as well as the study of edaphic factors were done in 2016 in Chameli Community Forest hill. Soil samples were taken from bottom, middle and top areas of east, centre and west reasons of the hill. During this study, *Schima wallichi* and *Rhododendron arboreum* were found dominant species and had less effect of edaphic factors. Similarly climber plants like *Smilax aspara, Smilax lancaefolia, Smilax ovalifolia* and *Dioscorea bulbifera* were absent in west area of top region which might be due to low content of moisture, pH, and phosphorous. *Scutellaria repens, Sida cordifolia, Solanum nigrum, Tripterospermum volubile, Carex baccans, Heteropogan contortus* etc. were absent in west areas of middle region which might be due to the effect of high % of sand, phosphorous and moisture content and has low % of silt, potassium and pH. Herbs are more dominant in bottom, trees in middle and shrubs in top region. The east area of bottom, middle and top region had more diverse vegetation. The average of organic matter percentage, nitrogen, potassium and phosphorous content was maximum in middle hill which supports the highly diversified tree species and dense forest. Phosphorous showed the most effective factor on plant distribution. Therefore, for the proper growth, functioning and abundance of plant species, edaphic factors had a significant effect and play an important role on plant distribution.

Keywords: Edaphic factors; Plant distribution; Soil collection

Introduction

Plants are distributed in all places such as low land, midland, high land and Himalayas. The distribution of plants mainly depends upon the environmental factors such as temperature, rainfall, elevation, aspect and soil conditions. Depending upon the elevation, the vegetation of Nepal is divided into Tropical forest (*Shorea robusta*) forest upto 1000m), Sub tropical forest (*Schima castanopsis*) and *Pinus roxburghii* up to 2000m, including midlands and Mahabharat range), Temperate forest (Oaks, Conifers and *Rhododendron* forest up to 2000 to 3000m), Sub alpine forest (*Abies, Birches* and *Juniper* forest up to 3000 to 4000m, Himalayas and Inner Himalayas) and Alpine forest (alpine shrub, e.g. *Primula*, stippes and cushions up to 4000m to 5000m). This type of distribution represents the vertical distribution. Similarly, horizontal distribution of plants or vegetation represents the distribution in east, centre and west. Shrestha A.M (1985) also studied the Distributional Analysis (Horizontal and Vertical) of plant species from Suryabinayak Forest area.

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Materials and Methods

Study Area

The study has been done in Chameli Community Forest, Bhaktapur, sub-tropical region of Nepal. It is a small hill facing the North-West with an altitude of 1590 masl with and area of 13.16 ha. There is popular temple called "Bindabasini" which lies at the centre of bottom region of the forest. There is an off-road passing through the bottom of the forest.

Plant Collection and Identification

Plant collection*:* Plants were collected from the hill by the following ways (Shrestha Malla, 2013). Plants having stem, leaves, flowers and fruits were collected for identification. Field notes were recorded in field book.

Plant Identification: Families of plants were identified on the basis of floral and gross morphology. Collected plant species were identified by different sources, such as Herbariums kept in Botany Department of Tri-Chandra College and KATH (National Herbarium and plant laboratories). Some plants were identified by 'Flora of British India, (Vol 1-5, 1872-1890) by Hooker.

Plant Distribution

For convenience of study of distribution of plants, vertically the hill was marked as Bottom (1400m), Middle (1495m) and Top (1590m) by the help of altimeter. This division is mainly based on altitude. Similarly, horizontally, the hill was divided into east, centre and west as shown in Table 1. The presence or absence of plant species in those nine areas were marked by '+' and '-' as shown in Table 2.

Soil analysis

Method of soil sampling: Soil samples were collected form "V" shaped notches (F.R.S.R.D, 1980). Soil samples were dried in air at room temperature and crushed gently with wooden pastel and mortar discarding pebbles and gravels. It was then sieved through 2 mm sieve and then it was again sieved through 0.2mm sieve for nitrogen and organic matter determination (F.R.S.R.D, 1980 and Jackson, 1967).

Physical Analysis of Soil

Moisture content, texture analysis and soil color determination was done.

A: Moisture content of soil (MC): Moisture content was determined by Petridish method.

B: Texture analysis*:* Texture analysis was done by "Cylinder method".

C: Color of soil*:* Nine different soil samples were determined by Paper method.

Chemical Analysis of Soil

A: pH*:* Soil pH was measured by "Single Electrode pH meter method ".

B: Organic matter (OM)*:* The soil organic matter was determined by Walkey-Black's method.

C: Total nitrogen (N): Total nitrogen of the soil was determined by modified Kjeldhal's method.

D: Phosphorous (P)*:* The available phosphorous was estimated by "Bray 2 method".

E: Available potassium (K)*:* The available potassium was determined by ammonium acetate extraction, flame photometric method (Corning-400).

Results and Discussion

Plant Distribution

According to the vertical and horizontal distribution of the plant species, the most dominant plant species in the Chameli Community forest were *Schima wallichi* and *Rhododendron arboreum* (Poudel, 2010). In an average, plants such as *Castanopsis indica*, *Castanopsis tribuloides*, *Urtica dioca*, *Pyrus pashia* and *Alnus nepalensis* were also dominant in this forest. Similarly, plant species such as *Celtis australis, Liqustrum confusum, Necotiana tabacum, Sida rhombifolia, Carex baccans, Curculigo orchioides, Osbeckia nepalensi*s etc were found very scattered in the forest.

Plant species like *Acyranthes aspara, Ageratum haustonianum, Amaranthus blitum, Crassocephalum crepidiodes, Drimaria cordata, Englehardtia spicata, Gaultheria fragrantissima, Gnaphalium leuto-album, Pterospermum acerifolium, Rumex dentatus, Salvia officinalis, Coniogramme fraxinae, Dicranopteris lanigera, Equisetum arvense, Lycopodium japonicum* were dominant in bottom region (1400 masl) whereas plants like *Celtis australis, Liqustrum confusum, Necotiana tabacum, Sida rhombifolia, Carex baccanas, Curculigo orchioides, Osbeckia nepalenis* were sparse in bottom region of the study area.

Similarly, plants species like *Semicarpus anacardium, Bambusa vulgare, Paspalum distinctum, Castanopsis indica, Castanopsis tribuloides, Rhododendron arboreum, Alnus nepalensis, Schima wallichi* were dominant in the middle region (1495 masl) whereas *Acaranthus aspera, Aesthynanthus parviflorus, Ageratum conyzoides, Ageratum haustonianum, Ajuga macrosperma, Anaphalis adnata, Anaphalis busua, Artimisia vulgure, Gnaphalium leuto-album, Hedera nepalensis, Hedyotis scandens, Isodon sacropulariodes, Ocimum barbatum, Osyris wightiana, Piper longum, Potentilla leschnaaltina, Rubus accuminatus, Scutellaria repens* were scattered in middle region of the study area.

Some plants species like *Fraxinus floribunda, Inula cappa, Ocimum barbatum, Ocimum basilium, Piper longum, Reinwardtia indica, Scutellaria discolor, Castanopsis indica, Castanopsis tribuloides, Cleyera ochnacea,*

Desmodium concinuum, Desmodium elegens, Englehardtia spicatata, Flemengia macrophylla, Syzigium jambolana, Zanthoxylum armatum, Cyperus compactus, Cyrtococcum patens were dominant on the top region (1590 masl) whereas *Gaultheria hookeri, Quercus glauca, Rubus accuminatus, Ajuga macrosperma, Anaphalis adnata, Choerospondias axillaris, Crepis japonica, Urtica dioca, Allium wallichi, Aleuritopteris bicolar* were sparse on the top region of the study area.

During the study, it was found that subtropical plants species cover much numerous than the high hill plant species. This is due to the low elevation (1400-1590m) of the study area. Horizontally, eastern elements were found more numerous than the western. Therefore, from the study of Chameli Community Forest it was revealed that the forest was slightly disturbed, non-polluted, highly diversified and interesting. The study would be helpful for the people who are willing to get information on floristic composition of Chameli Community Forest.

Both the patterns of plant distribution viz. horizontal as well as vertical were recorded from bottom (1400masl) to top (1590masl) as well as horizontally into east, centre and west area were recorded (Table 2).

Table 1: Representation of whole area.

Bottom (1400m)			Middle (1495m)			Top (1590m)		
East	Centre	West	East	Centre	West	East	Centre	West

Table 2: Horizontal and Vertical Distribution of plant species in Chameli Community Forest.

S.N.	Scientific name of plants	Bottom of the hill			Middle of the hill			Top of the hill		
		East	Centre	West	East	Centre	West	East	Centre	West
1	*Acaranthes aspera*, L.d.	+	+	+	+	-	-	-	-	-
2	*Aesthynanthus parviflorus*, (D.Don) Soreng.	+	+	+	+	-	+	-	+	-
3	*Agave cantula*, Roxb.	-	+	+	-	+	+	-	-	-
4	*Ageratina adenophora*, Soreng.	+	+	+	+	-	+	+	+	+
5	*Ageratum conyzoides*, L.	+	+	+	-	-	-	-	-	-
6	*Ageratum haustonianum*, Mill.	+	+	+	-	-	-	-	-	-
7	*Ajuga macrosperma*,Wall.ex.Benth.	-	+	-	+	-	-	-	+	-
8	*Alnus nepalensis*, D.Don.	+	+	+	+	+	+	-	-	-
9	*Amaranthus blitum*, Linn.	+	+	+	-	-	-	-	-	-
10	*Anaphalis adnata*, Sims.	+	-	+	-	-	+	-	-	-
11	*Anaphalis busua*, (Buch-Ham.ex.Don)DC.	-	-	-	-	-	+	-	+	+
12	*Artimisia vulgare*, Linn.	+	+	+	-	-	+	+	+	+
13	*Baenghaurium albiflora*,	-	-	-	-	-	-	+	-	+
14	*Berberis aristata*, DC.	-	-	-	+	+	+	+	+	+
15	*Bidens pilosa*, Linn.	+	+	+	+	-	+	+	+	+
16	*Bidens tripartita*, L.	+	+	+	+	-	+	-	-	-
17	*Buddleja asiatica*, Lour.	+	+	+	+	-	+	-	-	-
18	*Butea monosperma*, (Lam.)Kuntze.	-	-	-	+	-	+	-	-	-
19	*Camellia kissi*,Wall.	-	-	-	+	+	-			
20	*Castanopsis indica*, Sm.	+	+	+	+	+	+	-	+	+
21	*Castanopsis tribuloides*, Roxb.	+	+	+	+	+	+	-	+	+
22	*Celtis australis*, L.	-	+	-	+	+	-	-	-	-
23	*Centella asiatica*, (L.)Urban.	+	-	+	-	-	-	-	-	-
24	*Choerospondias axillaris*, (Roxb.) B.L.Brutt.A.W.Hill.	+	+	+	+	-	+	-	-	+
25	*Cirsium wallichi*, DC.	+	+	+	-	-	-	+	+	+
26	*Cissampelas pereira*, L.	+	+	+	+	-	+	+	+	+

Table 2: Horizontal and Vertical Distribution of plant species in Chameli Community Forest. (Contd.)

S.N.	Scientific name of plants	Bottom of the hill			Middle of the hill			Top of the hill		
		East	Centre	West	East	Centre	West	East	Centre	West
27	*Cleome gynandra*, L.	-	-	-	+	-	-	-	-	-
28	*Cleyera ochnacea*,Thumb.	+	+	-	+	+	-	-	+	+
29	*Crassocephalum crepidiodes* ,(Benth.)S.Moore.	+	+	+	-	-	-	-	-	-
30	*Crepis japonica*, L	+	+	+	-	-	-	+	-	-
31	*Cucumis callosus*, (Rottlb.)Coyn.	+	+	+	+	-	-	+	-	-
32	*Cuphea procumbens*. Cav.	-	-	+	+	-	+	-	+	+
33	*Desmodium concinuum*, DC.	-	-	-	-	-	-	+	+	+
34	*Desmodium elegans*, DC.	-	-	-	+	-	+	+	+	+
35	*Dioscorea bulbifera*. L.	+	+	+	+	+	+	-	-	-
36	*Drimaria cordata*, Willd.	+	+	+	-	-	-	-	-	-
37	*Elephantopus scaber*, Linn.	+	+	+	-	-	-	-	-	-
38	*Englehardtia spicata*, lech.	-	+	-	+	-	+	+	+	+
39	*Eribotrya dubai*,DC	-	-	-	+	+	+	+	-	_
40	*Eurya acuminata*, DC.	+	+	-	+	+	-	-	-	-
41	*Ficus benghalensis*,L.	+	+	+	-	-	-	-	-	-
42	*Ficus benjamina*, L.	-	+	-	+	-	+	-	-	-
43	*Ficus nerifolia*, Sm.	+	+	+	+	+	+	-	-	-
44	*Ficus religiosa*, L.	+	+	+	+	-	+	-	-	-
45	*Ficus sermentosa*, Duch-Ham.	-	+	+	-	-	-	-	-	-
46	*Flemengia macrophylla*, (Willd)Merr.	-	-	-	-	-	-	+	+	+
47	*Fraxinux floribunda*, Wall.	-	-	-	-	+	+	+	-	-
48	*Gaultheria fragrantissima*, Wall.	-	+	-	+	+	+	+	-	+
49	*Gaultheria hookeri*, C.B clarke.	-	-	-	+	+	+	+	+	+
50	*Gnaphalium leuto-album*, D.Don.	-	+	-	-	-	+	+	-	-
51	*Hedera nepalensis*, k.koch.	-	-	-	-	+	-	+	-	-
52	*Hedyotis scandens*, Roxb.	+	-	-	+	-	-	-	-	-
53	*Homalium nepalense*, COC-) Benth.	-	-	-	-	+	+	-	-	-
54	*Inula cappa* (Buch-ham.ex.D.Don) DC.	-	-	-	-	-	-	+	+	+
55	*Isodon sacropularioides*, (Wall.)Murata.	-	-	-	+	-	-	+	+	-
56	*Jasminum dispermum*, L	+	+	+	+	-	-	-	-	-
57	*Jasminum humile*, L.	-	+	-	-	-	-	-	-	-
58	*Lantana camara*, L	+	+	+	+	-	+	-	-	-
59	*Liqustrum confusum*, Decne.	-	-	+	-	-	-	+	-	+
60	*Litsea monopetala*, (Rbox.) pers.	-	-	+	+	-	+	-	-	-
61	*Lyonia ovalifolia*, Wall.	-	-	-	+	+	+	+	+	+
62	*Maesia chisia*, Buch-ham. ex.D.Don.	-	+	-	+	+	+	-	+	-
63	*Melastoma melabathricum*, L.	-	+	+	+	-	+	+	+	+
64	*Michelia champaca*, L.	+	+	+	+	+	+	-	-	-
65	*Myrica esculenta*,Buch-ham ex.D Don.	+	+	+	+	+	+	-	-	-
66	*Myrsine capitellata*, *W*all.	-	+	-	+	+	-	+	-	-
67	*Myrsine semiserrate*, Wall.	-	+	+	-	+	+	-	+	+
68	*Necotiana tabacum*, L.	+	-	-	-	-	-	-	-	-
69	*Nyctanthes arbor-tristis*, L.	+	-	-	-	-	-	-	-	-
70	*Ocimum barbatum*, L.	-	-	+	-	-	+	+	+	+

Table 2: Horizontal and Vertical Distribution of plant species in Chameli Community Forest. (Contd.)

S.N.	Scientific name of plants	Bottom of the hill			Middle of the hill			Top of the hill		
		East	Centre	West	East	Centre	West	East	Centre	West
71	*Ocimum basilicum*, L.	-	-	-	-	-	+	+	+	+
72	*Osyris wightiana*,Wall.ex.wight.	-	-	+	-	-	+	+	-	+
73	Oxalis latifolia, H.B.K.	+	+	+	-	-	-	-	-	-
74	*Phlomis setigeria*, Falc.ex.Benth.	+	+	+	-	-	-	-	-	-
75	*Phyllanthus emblica*, L.	+	-	+	-	-	-	-	-	-
76	*Phyllanthus parvifolium*, Buch-Ham.	+	+	+	-	-	-	-	-	-
77	*Piper longum*, Linn.	-	-	-	+	-	-	+	+	+
78	*Potentilla leschnaaltina*, Ser.	+	-	-	+	-	-	-	-	-
79	*Polygonum hydropiper* ,Linn.	+	+	+	+	-	-	-	-	-
80	*Prunus cerasoides* ,D.Don.	+	+	-	-	-	-	-	-	-
81	*Pterospermum acerifolium* ,(L.) Willd.	+	-	+	-	-	-	-	-	-
82	*Pyrus pashia*, Buch-Ham ex.	-	+	-	+	+	+	-	-	-
83	*Quercus glauca*,Thump.	-	-	-	-	+	+	+	-	-
84	*Reinwardtia indica*, Dumart.	-	-	-	-	-	-	+	+	+
85	*Reinwardtia trigyana*, Planch.	+	+	-	-	+	+	-	-	-
86	*Rhododendron arboreum*,	+	+	+	+	+	+	+	+	+
87	*Rhus javanica*, L.	+	+	-	-	-	-	-	-	-
88	*Rosa indica*, L.	+	+	-	-	-	-	-	-	-
89	*Rubus accuminatus*,T.ex sm.	+	-	+	+	-	-	+	-	-
90	*Rubus ellipticus*,Smith.	+	+	+	+	-	-	-	-	-
91	*Rumex dentatus*,L.	+	+	+	+	-	+	+	-	-
92	*Rungia himalayenthes*,C.B clarke.	-	+	-	-	-	-	-	-	-
93	*Salvia officinales*,	-	+	-	-	-	-	-	-	-
94	*Schima wallichii*, DC.	+	+	+	+	+	+	+	+	+
95	*Scutellaria discolor* ,Buch-Ham.	-	-	-	-	-	-	+	+	+
96	*Scutellaria repens* ,Buch-Ham.	+	+	+	+	-	-	-	-	-
97	*Semicarpus anacardium*,L.F.	+	-	+	+	+	-	-	-	-
98	*Sida cordifolia*,L.	+	-	+	+	+	-	-	-	-
99	*Sida rhombifolia*,L.	-	+	-	-	+	-	-	-	-
100	*Solanum aculeatissum.*	+	+	+	-	-	-	-	-	-
101	*Solanum nigrum*,Linn.	+	+	+	+	-	+	+	-	+
102	*Solena heterophylla*,Lour.	+	+	+	-	+	-	-	-	-
103	*Strobilanthus pentistimonoides*,Ness.	-	-	-	-	-	-	+	+	+
104	*Syzigium jambolana*,DC.	-	-	-	+	+	+	+	+	+
105	*Terminalio arjuna* ,(Roxb ex. DC) W.and .A.	-	-	-	+	+	+	-	+	+
106	*Tripterospermum volubile*, (D.Don) H.Hara.	+	+	+	+	-	+	+	-	+
107	*Urtica dioca*, Linn.	-	+	-	+	-	-	+	-	-
108	*Vigna angularis*,(Willd) Ohcoi&Ohashi.	-	-	-	-	-	+	+	+	-
109	*Zanthoxylum armatum*,DC.	-	-	-	-	-	+	+	+	+
110	*Zizypus incurva*,Roxb.	+	+	+	+	-	+	-	+	
S.N.	**Scientific name of plants (Monocot)**									
1	*Allium wallichi*, Kunth.	-	-	-	-	+	-	-	+	-
2	*Bambusa vulgare*, Schrad.	+	+	+	+	+	+	-	-	-
3	*Carex baccans*, Nees.	-	-	+	-	-	+	+	-	+

Table 2: Horizontal and Vertical Distribution of plant species in Chameli Community Forest. (Contd.)

S.N.	Scientific name of plants	Bottom of the hill			Middle of the hill			Top of the hill		
		East	Centre	West	East	Centre	West	East	Centre	West
4	*Carex filicina,* Nees.	-	-	+	-	-	+	+	-	+
5	*Cautleya spicata,* (J.E. Smith) Baker.	+	-	+	-	-	+	-	-	-
6	*Chlorophytum nepalense,* (Linal.) Baker.	-	-	+	-	-	+	-	-	-
7	*Curculigo orchioides,* Gaertn.	+	-	-	-	-	-	-	-	-
8	*Cyperus compactus,* Retz.	+	-	+	-	-	-	+	+	+
9	*Cyperus compressus,* L.	+	-	+	-	-	-	+	+	+
10	*Cyrtococcum patens,* (L.) A.Camus.	+	+	-	+	-	-	+	+	+
11	*Drepanostanchyum intermedium,* Keng.f.	+	+	+	-	-	+	-	-	-
12	*Digitaria ciliaris,* (Retz.)Koeler.	+	+	+	-	-	-	-	-	-
13	*Globba racemosa,* Sarro clarkei, baker	-	-	-	+	-	+	+	-	+
14	*Globba witinii,* S.m	-	-	-	+	-	+	+	+	+
15	*Heteropogan contortus,* (l.) Beauvois	+	+	+	-	-	-	-	-	-
16	*Hypericum japonicum,* Thumb-ex Murray	+	-	+	-	-	-	-	-	-
17	*Leea aspara,* L.	-	-	-	-	-	+	+	+	+
18	*Leersia hexandra* ,Sw.	-	-	-	-	-	+	+	+	+
19	*Ophiopogon clarkei,* Hook.	+	+	+	-	-	-	-	+	-
20	*Osbeckia nepalensis,* Hook.	+	-	-	-	-	+	+	-	+
21	*Paspalum distinchum,* L.	+	+	+	+	-	+	+	-	+
22	*Smilax aspera,* L.	+	+	+	+	-	-	+	-	-
23	*Smilax lancaefolia,* L.	+	+	+	+	-	-	-	-	-
24	*Smilax ovalifalia,* L.	+	-	+	+	-	-	-	-	-
25	*Thysanolaena maxima,* (Roxb.) D.Kuntze.	+	+	+	+	-	-	-	-	-
26	*Urochloa ramosa,* (L.).T.Q. Nguyen.	+	+	+	+	-	+	+	-	+
S.N.	**Scientific name of plants (Pteridophyta)**									
1	*Aleuritopteris bicolor,* (Roxb.).Fraser.Jenk.	+	-	+	-	+	+	+	-	-
2	*Athyrium foliolosum,* T.Moore.ex.R.Sim.	+	+	+	+	-	-	+	+	-
3	*Coniogramme fraxinae,* (D.Don)Fee.ex.Diels.	+	+	+	-	-	-	+	-	-
4	*Dicranopteris lanigera,* (D,Don)Fraser.Jenk.	+	+	+	-	-	-	-	-	-
5	*Diplopterygium giganteum,* (Wall.ex.Hook. and Bauer) Nakai.	+	+	-	-	-	-	-	-	-
6	*Dryopteris cochleata, (D.Don) c.chr.*	+	+	+	-	+	+	-	-	-
7	*Dryopteris sparsa,(D.Don) c.chr.*	+	+	+	+	-	+	-	-	-
8	*Equisetum arvense* L. subsp. *diffusum* (D.Don) Fraser-Jenk.	+	+	+	-	-	-	-	-	-
9	*Lycopodium japonicum,* Thump. Sw.	+	+	-	-	-	-	-	-	-
10	*Lygopodium japonicum,* Thump. Sw.	+	+	+	+	-	-	-	-	-
11	*Nephrolepsis cordifolia,* (L.) presl.	+	+	+	-	-	-	-	-	-
12	*Odontosoria echinesis,* (L) J.Sm.	+	+	+	-	-	-	-	-	+
13	*Oleandra wallichi,* (Willd.) Ching.	+	+	-	+	+	-	-	-	+
14	*Pteridum revolutom,* (Blume) Nakai.	+	+	-	-	-	+	-	-	-
15	*Tectaria coadunata.*	+	+	-	+	-	-	-	-	-
S.N.	**Scientific name of plants (Gymnosperm)**									
1	*Pinus roxburghi,* Sargent.	+	-	+	+	-	+	+	+	+
	Total Plants	**94**	**92**	**86**	**74**	**40**	**70**	**59**	**45**	**53**

Soil Analysis (Edaphic Factors)

Physical analysis

A. Moisture Content (MC%): When the moisture content were compared among east, centre and west areas of bottom region of the hill, high moisture percentage (4.2%) was found in west area while low (0.9%) in centre area of the bottom region of the hill. Similarly, when moisture % were compared among east, centre and west areas of middle region of the hill, high moisture % (4.8%) was found in west area while low (1.7%) in east area of the middle region of the hill. When moisture percentage were compared among east, centre and west areas of top region of the hill, high (4.2%) was noticed in centre area whereas low (0.8%) in west area of the top region of the hill.

Again, when moisture percentage were compared among east, centre and west areas of bottom, middle and top region, higher moisture % (4.8%) was found in west area of middle region and lower (0.8) in west region of the top region of the hill.

In an average, the highest (H) moisture percentage (3.0%) was recorded in middle region and the lowest (L) moisture % (2.3%) in top region of the hill (Table 3).

Herbs and trees sharply decreased in population on the top due to the lack of moisture (Lamichaney, 1995). Moisture of the soil is affected by texture and the amount of available water is low for the plants growing in coarse textured soil type (Olsen and Watanable, 1963). Soil moisture is highest in the west areas of middle region where vegetation abundance is low when compared with other in comparison with other areas (Table 3).

B. Texture: When the texture of soil from different areas of bottom, middle and top region of the Chameli Community forest were analyzed, different soil types were found (Table 3). Soil collected from the Chameli Community forest were analyzed into sand, loamy sand, sandy clay, sandy loam and loamy sand. The sand % was higher when compared to silt % and clay % (Table 3). Loam and silty soils have better water relation properties as it is best for the growth of plants (Kramer, 1949). The soil type of this forest varies from sandy to sandy loam soil where NPK content was moderate. Soil factors control and maintain vegetation growth (Shrestha, 1979). The middle region of the forest on vertical distribution showed the higher trees dominancy which prefer to grow in coarse textured soil type.

C. Color: The soil color helps to know the soil fertility of the area. The darker the soil, the more humus content present in it. The soil color in the study area were colorful such as brown, light brown, light red, brownish black, dark red, reddish brown and greyish brown (Table 3). The highest diversity of plant was found in east area of the bottom, middle and top region of the hill where the soil color was brownish and light brown. Similarly, the soil color has adverse effect on soil fertility (Howell, 1988).

Chemical Analysis of Soil

A. pH

When pH was compared among east, centre and west area of bottom region of the hill, high pH (6.8) was found in centre area while low (5.2) in west area of bottom region. Similarly, when pH was compared among east, centre and west areas of middle region, high (5.3) was recorded in west area whereas low (5.1) was found in east area of the middle region. When pH was compared among east, centre and west areas of top region, high (5.5) was found in centre region while low (5.0) in west area of top region.

Again, when pH was compared in east, centre and west areas of bottom, middle and top region, higher pH was found in (6.8) was found in centre areas of bottom region and lower (5.0) was recorded in west area of top region.

Table 3: Table showing the physical analysis of soil.

Parameters	Bottom of the hill				Middle of the hill				Top of the hill			
	East	Centre	West	Ave.	East	Centre	West	Ave.	East	Centre	West	Ave.
Sand	86.7↑	79.9	53.3↓	73.3L	79.9	86.7	86.7	84.4H	63.3	80.0	83.3	75.5
Silt	9.9	9.9	29.9↑	16.7H	16.7	6.7↓	6.7↓	9.9 L	19.9	13.3	9.9	14.4
Clay	3.3↓	10.0	16.7↑	10.0	3.3↓	6.7	6.7	5.6 L	16.7↑	6.7	6.7	10.02H
Soil type	Sand	Loamy sand	Sandy loam		Sandy loam	Loamy sand	Loamy sand		Loamy sand	Sandy loam	Loamy sand	
Soil color	Brown	Light brown	Light red		Light brown	Brownish black	Dark red		Reddish brown	Grayish brown	Light red	
Moisture	2.5	0.9	4.2	2.5	1.7	2.9	4.8↑	3.0 H	1.09	4.2	0.8↓	2.3 L

H= Highest, L= Lowest, ↑=Higher, ↓=Lower

In an average, the highest (H) pH (5.8) was found bottom region whereas the lowest (L) pH (5.2) in middle region of the forest (Table 4).

The higher pH was found in centre area of bottom region while lower in west area of top region. The soil was found to be less acidic, low phosphorous and high potassium at the bottom region (Table 4) which was suitable for herbs to grow vigorously (Baral, 1983). The growth of *Rhododendron arboreum* was dense in lower organic content and acidic soil in the west areas of the middle region as well as bottom region of hill (Pradhan and Ghimire, 1994).

B. Organic Matter (OM)

When organic matter was compared among east, centre and west areas of bottom region of the forest, high organic matter (4.9%) was found in east area and low (2.6%) in west area of the bottom region. Similarly, when organic matter was compared among east, centre and west areas of middle region high organic matter (6.4%) was found in centre area while low (2.4%) in east area of middle region. When organic matter was compared in east, centre and west areas of top region, high organic matter (4.2%) found in west area but low (1.9%) in centre area of top region of the hill.

Again, when organic matter was compared among east, centre and west areas of bottom, middle and top region, higher organic matter (6.4%) was found in centre area of middle region whereas lower (1.9%) in centre area of top region. In an average, the highest (H) organic matter (4.01%) was found in middle region while the lowest (L) organic matter (3.4%) in east area of top region (Table 4**).**

The higher organic matter was found in centre area of middle region whereas lower in centre area of top region. The middle region of the hill had highest content of organic matter, nitrogen, potassium and phosphorous (Table 4) in the soil which supports the large number of tree species to grow. The healthy growth of plant species requires the soil with all the minerals along with N, P, K, OM% etc. (Champion and Seth, 1968).

C. Nitrogen (N)

When nitrogen percentage was compared among east, centre and west areas of bottom region, high (0.25%) was found in east area while low (0.1%) in west area of bottom region of the hill. Similarly, when nitrogen percentage was compared among east, centre and west areas of middle region, high nitrogen (0.32%) was found in centre area while low (0.25%) in west area of middle region. When nitrogen % was compared among east, centre and west areas of top region, high (0.21%) nitrogen % was noticed in east area but low (0.1%) in centre area of top region (Table 4).

Again, when nitrogen percentage was compared among east, centre and west areas of bottom, middle and top region, higher nitrogen (0.32%) was found in centre area of middle region while lower (0.1%) in centre area of top region.

In an average, the highest (H) nitrogen (0.25%) was found in middle region whereas the lowest (0.16%) was found in top region of the forest.

Organic matter was very much related with pH and organic matter supplies mist of the nitrogen (Willem, 1990). The nitrogen content in the soil promote the proper growth and functioning of the plant species (Morphac et al, 1991). Nitrogen in the soil helps to increase soil structure and increase soil microorganism.

D. Phosphorous (P)

When phosphorous was compared among east, centre and west areas of bottom region, high phosphorous (50.4kg/h) was found in west area while low (18.3kg/h) in centre area of bottom region. Similarly, when phosphorous was compared among east, centre and west areas of middle region, high phosphorous (160.3kg/h) was found in west area while low (18.3kg/h) in centre area of middle region. When phosphorous was compared among east, centre and west areas of the top region, high phosphorous (91.6kg/h) was found in centre area whereas low (18.3kg/h) in west area of top region.

Table 4: Table showing the chemical properties of the soil

Parameters	Bottom of the hill				Middle of the hill				Top of the hill			
	East	Centre	West	Av.	East	Centre	West	Av.	East	Centre	West	Av.
pH	5.5	6.8↑	5.1	5.8 H	5.1	5.2	5.3	5.2 L	5.4	5.5	5.0↓	5.3
OM%	4.9	3.3	2.6	3.6	2.4	6.4↑	3.2	4.01 H	3.4	1.9↓	4.2	3.4 L
N_2	0.25	0.2	0.1↓	0.18	0.3	0.32↑	0.2	0.25 H	0.21	0.1↓	0.2	0.16 L
P kg/h	41.2	18.3↓	50.4	36.6 L	50.4	18.3↓	160.3↑	76.3 H	22.9	91.6	18.3↓	44.3
Kkg/h	122.1	134.3	152.6	136.4 H	225.9↑	116.01	67.2↓	136.4	73.3	116.01	122.1	103.8 L

H= Highest, L= Lowest, ↑=Higher, ↓=Lower

Again, when phosphorous was compared in east, centre and west areas of bottom, middle and top region higher phosphorous (160.3 kg/h) was found in west area of middle region while low (18.3 kg/h) in centre areas of bottom and middle region as well as west area of top region.

In an average, the higher (H) phosphorous content (76.3kg/h) was found in middle region while the lowest (L) phosphorous (36.6kg/h**)** in bottom region of the hill (Table 4**).** The higher percentage of phosphorous in the west area of middle region showed medium plant diversity with dominant trees (Juwa, 1989).

E. Potassium (K)

When potassium was compared among east, centre and west areas of bottom region, high potassium (152.6kg/h) was found in west area while low (122.1kg/h) in east area of bottom region. Similarly, when potassium was compared among east, centre and west areas of middle region, high (225.9 kg/h) was found in east areas while low (67.2kg/h) in west area of middle region. When potassium was compared among east, centre and west areas of top region, high (122.1kg/h) was found in west area but low (73.3kg/h) in east area of top region.

Again, when potassium was compared in east, centre and west areas of bottom, middle and top region, higher potassium (225.9kg/h) was found in west area of bottom region while lower (67.2 kg/h) in west area of middle region.

In an average, the highest (H) potassium was found in middle region whereas the lowest (L) potassium was found in top region of the hill (Table 4).Vigorous growth of the herb species in the bottom region of the hill was due to the highest potassium content of soil and sand fraction increase with decreases in potassium (Failyer (1908).

Effect of Edaphic Factors on Plant Distribution

Dominant species i.e. which are found in both horizontal and vertical distribution pattern such as bottom (east, centre and west), middle (east, centre and west) and top (east, centre and west) of the Chameli Community Forest hill were *Schima wallichi* and *Rhododendron arboreum* (Bhattarai and Vetaas, 2006). So, these two species favors to grow in all type of soil factors such as sand % (high and low), silt (high and low), clay % (high and low), different types of soil such as sand, sandy loam, loamy sand, sandy clay loam etc. Similarly, they can grow in light brown to dark red color of the soil. The study showed that these two species might have less effect of low as well as high soil moisture pH, N, P, K and OM%.

Edaphic factor has great role in distribution of plants. Vegetation varies greatly with edaphic factor. A slight change in nitrogen, phosphorous, potassium and organic matter have adverse impact on vegetation found in an area. Plant species such as *Necotiana tabacum, Nyctanthes arbor- tristis, Salvia officinales* and *Curculigo orchiodes* were present only in one area (east) of bottom region. These plants species might have effected due to less acid soil and low phosphorous content of the soil. The plant species, which were found only in one area (centre) of bottom region, were *Jasminum humile* and *Rungia himalayenthes*. This might be due to the effect of high silt and clay %.

Plant species as *Prunus cerasoides, Rhus javanica, Rosa indica, Diplopterygium giganteum* and *Lycopodium japonicum* were found in two areas (east and centre) of bottom region, which might be due to the effect of low organic matter and low phosphorous content of the soil. Similarly, plants like *Butea monosperma, Hedyotis scandens, Homaliun nepalense, Potentilla leschanaaltina, Sida rhombifolia, Allium wallichi* and *Chlorophytum nepalense* were found in east and centre areas of middle region which might have effected due to high phosphorous content of the soil.

Plant species like *Ageratum haustonianum, Ageratum conyzoides, Ajuga macrosperma, Amaranthus blitum, Anaphalis adnata, Centella asiatica, Crassocephalum crepidiodes, Drimaria cordata, Elephantopus scaber, Ficus benghalensis, Ficus nerifloia, Oxalis latifolia, Phlomis setigera, Phyllanthus parvifolium, Solanum aculeatissium, Solanum nigrum, Cautleya spicata, Digitaria ciliaris, Heteropogan contortus, Smilax ovalifolia, Dicranopteris lanigera, Equisetum debile, Nephrolepsis cordifolia, Odontosoria echinesis, Pteridium revolutom* and *Tectaria coadunate* were found in three areas (east, centre and west) of bottom region. This might be the effect of less acidic soil and low phosphorous content.

Plant species such as *Artimisia vulgare was present in seven areas* except east and centre areas of middle region, which might be due to the effect of high organic matter in those areas. Plants like *Scutellaria, repens, Sida cordifolia, Solanum nigrum, Tripterospermum volubile. Carex baccans, Heteropogan contortus* etc. were absent in west areas of middle region due to presence of high % of phosphorous. Similarly, plant such as *Butea monosperma, Hedyotis scandens, Homaliun nepalense, Potentilla leschanaaltina, Sida rhombifolia, Allium wallichi* and *Chlorophytum nepalense* were found in east and centre areas of middle region, which might be due to the presence of less % of phosphorous and not suitable to grow in high % of phosphorous. However, *Cirsium wallichi* was absent in middle region while *Melastoma melabathricum* and *Pinus roxburghi* were present in seven areas of high % of phosphorous except east and centre areas of bottom region which might be due to less % of phosphorous.

Similarly climber plants like *Smilax aspara, Smilax lancaefolia, Smilax ovalifolia* and *Dioscorea bulbifera* were absent in west area of top region with low % of phosphorous, whereas *Necotiana tabacum, Nyctanthes*

arbor- tristis, Salvia officinales and *Curculigo orchiodes* were present only in one area (east) of bottom region which favour to grow in medium amount of phosphorous. *Prunus cerasoides, Rhus javanica, Rosa indica, Diplopterygium giganteum* and *Lycopodium japonicum* were found in two areas (east and centre) of bottom region, and plant species like *Ageratum haustonianum, Amaranthus blitum, Anaphalis adnata, Centella asiatica, Solanum nigrum, Cautleya spicata, Digitaria ciliaris, Heteropogan contortus, Equisetum debile, Nephrolepsis cordifolia,* etc were found in three areas (east, centre and west) of bottom region. While *Syzigium jambolana, Terminalio arjuna, Litsea monopetala, Gnaphalium Leuto-album, Berberis aristata, Desmodium elegans, Eribotrya dubai etc*. were absent in botton region which might be due to presence of low % of phosphorous.

The plant species such as *Bidens pilosa, Cissampelas Pereira* and *Eupatorium adenophorum* were present in eight areas except centre area of middle region, which had high organic matter content in the soil so these plants did not prefer to grow which might be due to the effect of high organic matter. The plant species like *Castanopsis indica* and *Castanopsis tribuloides* were not found in east area of top region. The east area of top region had low nitrogen content in the soil so these plants might have effect to low content of nitrogen. Some plants such as *Syzigium jambolana, Terminalio arjuna, Litsea monopetala, Gnaphalium Leuto-album, Berberis aristata, Desmodium elegans, Eribotrya dubai etc*. were absent in botton region which might be due to the effect of low sand % and phosphorous content while high silt % and pH.

Some plants like *Bidens tripartia, Buddleja asiatica, Dioscorea bulbifera, Michelia champaca, Myrica esculenta, Dryopteris sparsa, Pteridum revolutom* etc. were absent only in top region which might be due to the effect of high clay %, low moisture content, organic matter, nitrogen and potassium content of the soil. Similarly *Cirsium wallichi* was absent in middle region which might be due to the effect of high % of sand ,moisture content, organic matter, nitrogen, phosphorous and potassium while it has low % of silt , clay and pH. Altitude is an important factor as herbs are dominant in bottom, trees in middle and shrubs in top. There is a relationship between edaphic factor and vertical ecological zones of Nepal (Shrestha A.M. (Malla) (2013).

Conclusions

During the study of effect of edaphic factors on plant distribution, it was found that the plant species which were present in all area of the bottom, middle and top region eg. *Schima wallichi* and *Rhododendron arboreum* had less effect of physical and chemical soil factors. They could grow in a slight change in pH, N, P, K and OM content of the soil. Plant species such as *Necotiana tabacum, Nyctanthes arbor- tristis, Salvia officinales* and *Curculigo orchiodes* were present only in one area (east) of bottom region. These plants species might have effected due to less acidic soil and low phosphorous. The plant species, which were found only in one area (centre) of bottom region, were *Jasminum humile* and *Rungia himalayenthes* which might be due to the effect of high silt and clay %. Good quality of soil, which favors the growth of large number of vegetation, was found in middle hill. The average of organic matter percentage, nitrogen, potassium and phosphorous content was maximum in middle hill, which supports the highly diversified tree species and dense forest.

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