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

Sarita Chaulagain* and Anjali Maiya Shrestha –Malla

1Department of Botany, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal.

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 lancaeofolia, 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.
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, Liquastrum confusum, Necotiana tabacum, Sida rhombifolia, Carex baccans, Curculigo orchoides, Osbeckia nepalensis etc were found very scattered in the forest.

Plant species like Acanthrus aspera, Ageratum haustorionanum, Amaranthus blitum, Crassocephalum crepidoiodes, Primula cordata, Englehardtia spicata, Gaultheria fragrantissima, Gnanphalium leuto-album, Pterospermum acerifolium, Rumex dentatus, Salvia officinalis, Coniogramme fraxinace, Dicranaopteris lanigera, Equisetum arvense, Lycopodium japonicum were dominant in bottom region (1400 masl) whereas plants like Celtis australis, Liquastrum confusum, Necotiana tabacum, Sida rhombifolia, Carex baccanas, Curculigo orchoides, Osbeckia nepalensis were sparse in bottom region of the study area.

Similarly, plants species like Semecarpus ancardium, Bambusa vulgare, Paspalum distinctum, Castanopsis indica, Castanopsis tribuloides, Rhododendron arboreum, Alnus nepalensis, Schima wallichi were dominant in middle region (1495 masl) whereas Acanthus aspera, Aesthynanthus parviflorus, Ageratum conyzaoides, Ageratum haustorionanum, Ajuga macroasperma, Anaphalis adnata, Anaphalis busua, Artimisia vislia, Gnanphalium leuto-album, Hedera nepalensis, Hedysceis scandens, Isodon sacropularioides, Ocimum barbatum, Osyris wightiana, Piper longum, Potentilla lebuchaalaina, Rabus acumnatus, 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 elegans, Engelhardtia spicata, Flemengia macrophylla, Syzigium jambolana, Zanthoxylum armatum, Cyperus compactus, Cyrtococcus patens were dominant on the top region (1590 masl) whereas Gaultheria hookeri, Quercus glauca, Rubus acuminitus, Ajuga macropetala, Anaphalis adnata, Choerospondias axillaris, Crepis japonica, Urtica dioca, Allium wallichii, Aleuriotepes 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        |
| West           | East           | Centre      |
| West           | East           | Centre      |

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    | Ageratina adenophora, L.   |      |        |      |      |        |      |      |        |      |
| 2    | Ageratum conyzoides, L.    |      |        |      |      |        |      |      |        |      |
| 3    | Ageratum haustoriumanum, M. |      |        |      |      |        |      |      |        |      |
| 4    | Agave cantula, Roxb.       |      |        |      |      |        |      |      |        |      |
| 5    | Ajuga macrosperma, Wall.ex.Benth. |      |        |      |      |        |      |      |        |      |
| 6    | Alnus nepalensis, D.Don.   |      |        |      |      |        |      |      |        |      |
| 7    | Amaranthus blitum, Linn.   |      |        |      |      |        |      |      |        |      |
| 8    | Anaphalis busua, (Buch-Ham.ex.Don)DC. |      |        |      |      |        |      |      |        |      |
| 9    | Aesthynanthus parviflorus, (D.Don)Soreng. |      |        |      |      |        |      |      |        |      |
| 10   | Anaphalis adnata, Sims.    |      |        |      |      |        |      |      |        |      |
| 11   | Artimisia vulgare, Linn.   |      |        |      |      |        |      |      |        |      |
| 12   | Baehnhaarium albiflora,    |      |        |      |      |        |      |      |        |      |
| 13   | Berberis aristata, DC.     |      |        |      |      |        |      |      |        |      |
| 14   | Bidens pilosa, Linn.       |      |        |      |      |        |      |      |        |      |
| 15   | Bidens tripartita, L.      |      |        |      |      |        |      |      |        |      |
| 16   | Buddleja asiatica, Lour.   |      |        |      |      |        |      |      |        |      |
| 17   | Butea monosperma, (Lam.)Kuntze. |      |        |      |      |        |      |      |        |      |
| 18   | Camellia kissi, Wall.      |      |        |      |      |        |      |      |        |      |
| 19   | Castanopsis indica, Sm.    |      |        |      |      |        |      |      |        |      |
| 20   | Castanopsis tribuloides, Roxb. |      |        |      |      |        |      |      |        |      |
| 21   | Celtis australis, L.       |      |        |      |      |        |      |      |        |      |
| 22   | Centella asiatica, (L.)Urban. |      |        |      |      |        |      |      |        |      |
| 23   | Cheirospondias axillaris, (Roxb.) B.L.Brutt.A.W.Hill. |      |        |      |      |        |      |      |        |      |
| 24   | Cissampelas pereira, L.    |      |        |      |      |        |      |      |        |      |

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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 ochneae, Thumb.              | + + -              | + + +              | - - -            |
| 29   | Crassocephalum crepidioides, (Benth.)/S.Moore. | + + -              | + + +              | - - -            |
| 30   | Crepis japonica, L.                  | + + +              | - - -              | - + +            |
| 31   | Cucumis callosus, (Rottl.)Coyn.      | + + +              | - - -              | + + +            |
| 32   | Cuphea proeminentis. Cav.            | - - +              | + + -              | + + -            |
| 33   | Desmodium conicum, DC.               | + + +              | + + -              | + + -            |
| 34   | Desmodium elegans, DC.               | + + +              | + + -              | + + -            |
| 35   | Dioscorea bulbifera. L.              | + + +              | + + -              | + + -            |
| 36   | Drimaria cordata, Wild.              | + + +              | - - -              | - - -            |
| 37   | Elephantopus scaber, Linn.           | + + +              | - - -              | + + +            |
| 38   | Engleharditia spicata. lech.         | - + -              | + + -              | + + +            |
| 39   | Eriobotrya dubia, 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   | Fraxinus floribunda, Wall.           | - - -              | + + +              | - - +            |
| 48   | Gaultheria fragrantissima, Wall.     | - + -              | + + +              | + + +            |
| 49   | Gaultheria hookeri, C.B clarke.      | - - -              | + + +              | + + +            |
| 50   | Gnaphalium leuto-album, D.Don.       | - + -              | - - -              | + + +            |
| 51   | Hedera nepalensis, k.koch.           | - - -              | + + -              | + + -            |
| 52   | Hedystis 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   | Liquistium confusum, Decne.          | - + -              | - - -              | + + -            |
| 60   | Litsea monopetala, (Rbox. ) pers.    | - - -              | + + -              | + + -            |
| 61   | Lyonía ovalfolia, 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, Wall.           | - + +              | + - -              | - - -            |
| 67   | Myrsine semiserrate, Wall.           | - + +              | + - -              | - - -            |
| 68   | Necotiana tabacum, L.                | + - -              | - - -              | - - -            |
| 69   | Nucif faintes arbor-tristis, L.      | + - +              | - - -              | - - -            |
| 70   | Ocimum barbatum, L.                  | - + -              | + + -              | + + +            |
| 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 leschnautilina, 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 trigysana, 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  | Strobilanthes pentistimonooides,Ness. | -    | -      | -    | -    | -      | -    | +    | +      | +    |
| 104  | Syzigium jambolana,DC.   | -    | -      | -    | +    | +      | +    | +    | +      | +    |
| 105  | Terminalia arjuna , (Roxb ex. DC) W and .A. | -    | -      | -    | +    | +      | -    | +    | +      | +    |
| 106  | Tripterospermum volubile , (D.Don) H.Hara. | +    | +      | +    | -    | +      | -    | +    | +      | +    |
| 107  | Urtica dioica, Linn.     | -    | +      | -    | -    | -      | -    | +    | +      | -    |
| 108  | Vigna angularis,(Wildl) Ohcoti&Ohashi. | -    | -      | -    | -    | +      | -    | +    | +      | -    |
| 109  | Zanthoxylum armatum,DC.  | -    | -      | -    | -    | +      | +    | +    | +      | +    |
| 110  | Zizyphus incurva,Roxb.   | +    | +      | +    | -    | +      | -    | +    | +      | +    |

**S.N. Scientific name of plants (Monocot)**

1. **Allium wallichi, Kunth.**
   - - - - + - - - + -
2. **Bambusa vulgaris, 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 |
| 1    | Aleuritopteris bicolor, (Roxb.)Fraser.Jenk. | +      | -      | +    | -    | +      | -    | +    | -      | -    |
| 2    | Athyrium foliolum, T.Moore.ex.R.Sim. | +      | +      | +    | -    | -      | +    | -    | +      | -    |
| 3    | Coniogramme fraxiniae, (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   | Lycopodium japonicum, Thump. Sw. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 11   | Nephrolepis cordifolia, (L.) presl. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 12   | Odontosoria echinesis, (L) J.Sm. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 13   | Oleandra wallichii, (Willd.) Ching. | +      | -      | +    | -    | -      | -    | -    | -      | -    |
| 14   | Pteridium revolutum, (Blume) Nakai. | +      | +      | -    | -    | -      | -    | -    | -      | -    |
| 15   | Tectaria coadunata. | +      | +      | +    | -    | -      | -    | -    | -      | -    |

| S.N. | Scientific name of plants (Pteridophyta) |
|------|------------------------------------------|
| 1    | Aleuritopteris bicolor, (Roxb.)Fraser.Jenk. | +      | -      | +    | +    | +      | -    | -    | +      | -    |
| 2    | Athyrium foliolum, T.Moore.ex.R.Sim. | +      | +      | +    | -    | +      | +    | -    | -      | +    |
| 3    | Coniogramme fraxiniae, (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   | Lycopodium japonicum, Thump. Sw. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 11   | Nephrolepis cordifolia, (L.) presl. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 12   | Odontosoria echinesis, (L) J.Sm. | +      | +      | +    | -    | -      | -    | -    | -      | -    |
| 13   | Oleandra wallichii, (Willd.) Ching. | +      | -      | +    | -    | -      | -    | -    | -      | -    |
| 14   | Pteridium revolutum, (Blume) Nakai. | +      | +      | -    | -    | -      | -    | -    | -      | -    |
| 15   | Tectaria coadunata. | +      | +      | +    | -    | -      | -    | -    | -      | -    |

| S.N. | Scientific name of plants (Gymnosperm) |
|------|----------------------------------------|
| 1    | Pinus roxburghii, 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 soil type. 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↓   | 6.7L  | 9.9L  | 19.9   | 13.3   | 9.9   | 14.4  |
| Clay       | 3.3↓   | 10.0   | 16.7↑ | 10.0  | 3.3↓   | 6.7    | 6.7   | 5.6L  | 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

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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 (3.4%) in east area of top region (Table 4) which was suitable for herbs to grow vigorously (Baral, 1983). The growth of plant species requires 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          | 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 |
| Kg/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

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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 (Juw, 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 wallichii 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 officinale and Curculigo orchidodes were present only in one area (east) of bottom region. These plants species might have effected due to less acidic 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, Potentillia 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 haustorianum, Ageratum conyzoides, Ajuga macroperma, Amaranthus blitum, Anaphalis adnata, Centella asiatica, Crascocephalum crepidiodes, Drimaria cordata, Elephantopus scaber, Ficus benghalensis, Ficus nervifolia, Oxalis latifolia, Phlomis setigera, Phyllanthus parvifolium, Solanum aculeatissimum, Solanum nigrum, Caulleya spicata, Digitalia ciliaris, Heteropogon contortus, Smilax ovalifolia, Dicranopteris lanigera, Equisetum debile, Nephrilepsis cordifolia, Odontosoria echinosis, Pteridium revolutum 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 vulgaris 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, Heteropogon 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, Potentillia 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 wallichii was absent in middle region while Melastoma melabathricum and Pinus roxburghii 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

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arbor- tristis, Salvia officinales and Curculigo orchioides 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 haustoriantum, Amaranthus blitum, Anaphalis adnata, Centella asiatica, Solanum nigrum, Caulaya spicata, Digitaria ciliaris, Heteropogon contortus, Equisetum debile, Nephrolepsis cordifolia, etc. were found in three areas (east, centre and west) of bottom region. While Syzygium jambolana, Terminalia arjuna, Litsea monopetala, Gnaphalium Leutoalbum, Berberis aristata, Desmodium elegans, Erubotrya dubai etc. were absent in bottom 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 Syzygium jambolana, Terminalia arjuna, Litsea monopetala, Gnaphalium Leuto-album, Berberis aristata, Desmodium elegans, Erubotrya dubai etc. were absent in bottom region which might be due to the effect of low sand % and phosphorous content while high silt % and pH.

Some plants like Bidens tripartita, Buddleja asiatica, Dioscorea bulbifera, Michelia champaca, Myrica esculenta, Dryopteris sparsa, Pteridium revolutum etc. were absent only in top region which might be due to effect of high sand %, 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 orchioides 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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