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Analysis of Changing Vegetation Pattern Under Different Climatic, Edaphic and Altitudinal Factors of Doon Valley, Uttarakhand, India

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ABSTRACT

The present study was conducted in altitudinal variable hight and soil pH growing vegetation of Doon valley that the soil type found in Mussoorie is generally medium loamy but its composition, moisture, and pH generally varied from place to place. Higher silt in Mussoorie was due to higher precipitation in the form of winter snow above 1800 m. Soil temperature in Mussoorie ranged from 4^0C –16^0C, while that of Sahastradhara and sudhowala was 15–19^0C. Soil organic matter content tended to be higher in high altitude and increased with increasing altitude. In this study, we observed that Soil temperature in Mussoorie ranged from 4^0–16^0C, while that of Sahastradhara was 15–19^0C, Sudhowala 15–25^0C. Soil organic matter, content tended to be higher in increase high altitudinal gradient. As per altitudinal variation and soil pH in this region dominant family of angiosperms in Garhwal Himalaya is Asteraceae, Brassicaceae, Cyperaceae, Fabaceae, Lamiaceae, Poaceae, Ranunculaceae, Polygonaceae, Amaranthaceae, Solanaceae, Sexifragaceae, Ranunculaceae Orchidaceae, Apocynaceae, Rutaceae, and Rosaceae.

Key-words: Altitude, Altitudinal Factors Angiosperms, Edaphic, Phytodiversity, Species analysis, Vegetation Pattern

INTRODUCTION

Himalaya being the richest biogeographically zones in India is provided with diverse vegetation. The location, climate, topography and other environmental factors of Himalaya have enriched it with diverse life forms. The Himalaya blooming with rivers, frozen glaciers, high mountain peaks that remain loaded with snow for most of the time, evergreen lakes, with the enormous diversity of flora (50% of the Indian subcontinent) is rightly called as the “Abode of God”. Due to cyclic climate changes mainly by anthropogenic activities, floral diversity of Himalaya is influenced to a large extent.

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Garhwal Himalaya is one among the most fascinating segment of a Himalayan arc and unique in its geology. Garhwal Himalaya is a great attraction to geologists and ecologists from all over the world because of its richness in biodiversity and it is the confluence of all rock formations resulting in different soil types and hence diverse vegetation types [1].

The Climate of Garhwal Himalaya varies from dry to moist conditions which have a great influence on growth, vitality and distribution of floristic vegetation. Garhwal Himalaya is a mass of intricate folding and faulting and is composed of igneous, sedimentary and metamorphic rocks [2]. Garhwal Himalaya has been extensively surveyed in terms of vegetation by many workers and floral diversity has been explored to a large extent [3,4], since the native floristic biodiversity of these restored sites of Doon valley is facing serious threats from anthropogenic activities, urbanization, and climate change, so the main aim of the study was to analyze the

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present status of the angiospermic vegetation of these sites.

MATERIALS AND METHODS

Study site- The present study was conducted in degraded and restored limestone mines of Doon valley, viz: Sudhowala, Sahastradhara, and Mussoorie. The areas were observed phytosociologically from February to May 2017.

Doon Valley (Area 3008 sq. km) is situated between foothills of Garhwal Himalaya and Shiwaliks at an altitude of 2200 ft above sea level. The area lies between 30.3840 N and 77.9739 E and receives an annual rainfall of 2073.3 mm. The east and west boundaries of Doon valley are limited by rivers Ganga and Yamuna respectively.

The climate of an area is temperate, although it varies from tropical to cold depending on the season and altitude. The average maximum and minimum temperatures are 27.65^{0}C and 13.8^{0}C respectively [5]. The study area was divided into three sub-areas viz. Sudhowala, Sahastradhara, and Mussoorie. In the study site, different types of angiospermic families were recorded which show biodiversity variability with varying Soil pH and climatic condition.

Sampling- Soil samples were collected from three different sites (Sudhowala, Sahastradhara and Mussoorie) from the uppermost part (5”-8”) as well as dried properly and preserved for pH measurement.

Soil temperature measurement- The study area was repeatedly visited to measure the soil temperature by a soil thermometer. Temperature measurement was done in 26th of Feb and 5th of March in Mussoorie, 3rd of March and 15th of March in Sahastradhara and 20th of Feb, 08th of March and 18th of March in Sudhowala.

Field survey and Data Collection- Extensive field surveys were conducted repeatedly from February to April in all the three different sites viz Sudhowala, Sahastradhara, and Mussoorie to observe the natural habitats and to collect the plant specimens. Various other parameters such as altitude, measurement of soil temperature and vegetation types were recorded. For plant identification purposes herbarium of Forest Research Institute of India and the herbarium of Botanical Survey of India northern region were used. Plant specimens were classified on the basis of habit and life forms as by Raunkiaer [6] and distribution of the pattern follows as per Odum [7].

Soil sample collection and Measurement of soil pH- Soil samples collected from all the three different sites were dried properly and sieved (2 mm). Different soil solutions were made by dissolving soil in distilled water. Analysis of soil pH and altitudinal variation was done as described by Schoenholtza *et al.* [8]; Raina and Gupta [9]; Arya [10].

RESULTS

Garhwal Himalayan is one of the most fascinating segments of the Himalayan arc and is unique in its geological setting, and so the unique floristic vegetation. A variety of factors contribute to the diversity of floristic vegetation in the study area. The dominance of *Lantana camara, Ageratum conyzoides, Eupatorium adenophorum, Parthenium hysterophorus, Mallotous phillipensis, Shorea robusta, Amaranthus spinosus, Euphorbia hirta, Rumex hastatus,* and *Clerodendrum viscosum* in the study area possibly shows the availability of optimum conditions for their growth. The uniform abundance of *L. camera, A. conyzoides* and *P. hystoriphorus* is due to their environmental plasticity, as they are shaded and light tolerant.

Soil pH of different regions of Doon Valley- Soil samples were collected from Mussoorie, Sahastradhara, and Sudhowala regions of Doon valley during February to April 2017. Soil samples were collected from the top soil (15 cm depth). Soil samples were stored under proper conditions and then were used for pH test by using Glass electrode pH meter. Soil temperature was measured by a soil thermometer.

(a) In Sudhowala region of the study area, soil pH varied from 5.4–7.40.

(b) In Sahastradhara region of the study area, soil pH ranged from 5.5–7.80.

(c) In Mussoorie region of the study area, soil pH ranged from 5.2–8.20.

The possible reason for the low pH value of Sudhowala soil sample is due to excessive leaching of minerals as compared to adjacent areas of Doon valley. The pH differed significantly between land use systems; soil pH of natural woodlands is lower than of remaining land-use systems.

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During the study period the angiospermic plant diversity, which included herbs, shrubs, climbers, and trees at changing pH patterns in three different communities of Doon valley, the dicot families were found in abundance as compared to monocot families which contribute a little percentage.

In community 1st as many as 33 angiospermic families having 62 genera and 76 species were observed, of which 7 were monocot families viz. Poaceae, Musaceae, Orchidaceae, Cannaceae, Zingiberaceae, and Liliaceae. Among monocot families, Poaceae is represented by the highest number of species (6). The important members of the family found in the study area were *Cyanodon dactylon, Poa annua, Triticum aestivum, Dendrocalmus giganteus* and *Saccharum officinarium*. Dicots were mainly represented by Malvaceae, Solanaceae, Euphorbiaceae, Asteraceae, Convolvulaceae, and Verbinaceae. Among dicots, Solanaceae showed the highest number of species (6) and is mainly represented by *Datura stramonium, Solanum torvum,* and *S. melongena*.

In community 2nd a total of 35 angiospermic families having 59 genera and 65 species were observed, of which monocots were represented by only two families viz. Poaceae, and Cyperaceae. Poaceae showed the highest number of species, the most important among them are *Apluda mutica*, *C. dactylon*, *P. annua* and *S. officinarium*. Cyperaceae is represented by a single species *Cyperus rotundus*. Among Dicot families Solanaceae and Asteraceae have shown the highest number of species (5 each). The important members of Solanaceae found in the area are *S. nigrum*, *Lycopersicon esculentum*, and *D. stramonium*. The important species of the Asteraceae family found in the area are *E. adenophorum, Xanthium indicium, A. conyzoides,* and *Bidens biternata*.

Furthermore, community 3rd also showed similar results, i.e. dominance of dicot families. A total of 30 families having 63 genera and 75 species of angiosperms and were observed, of which monocots were represented by only 3 families viz. Cyperaceae, Poaceae, and Melanthiaceae, all represented by a single species viz. *C. rotundus*, *C. dactylon*, and *Paris polyphylla* respectively. Among dicots, family Rosaceae is represented by the highest number of species (12), the important members of the family found in the study area are *Fragaria indicia*, *Rubus ellipticus*, *Rosa moschata, Prunus persica*, and *Pyrus pashia*. Some other important dicot families found in this community are Ranunculaceae, Fabaceae, Lamiaceae, Malvaceae, Salicaceae, Rubiaceae, Asteraceae, Solanaceae, and Polygonaceae. At changing altitude and soil pH of three different sites of Doon valley, the angiospermic vegetation of different sites is given in three separate lists.

Table 1: Community first shown the following angiospermic plant species at a pH range of 5.4–7.40

S. No.	Botanical name	Family	Division
1.	*Mangifera indica*	Anacardiaceae	Dicot
2.	*Anacardium accidentale*	Anacardiaceae	Dicot
3.	*Gossypium hirsutum*	Malvaceae	Dicot
4.	*Sida acuta*	Malvaceae	Dicot
5.	*Sida cordata*	Malvaceae	Dicot
6.	*Datura stramonium*	Solanaceae	Dicot
7.	*Solanum torvum*	Solanaceae	Dicot
8.	*Lycopersicum esculentum*	Solanaceae	Dicot
9.	*Capsicum* sp.	Solanaceae	Dicot
10.	*Solanum xanthocarpus*	Solanaceae	Dicot
11.	*Solanum melongena*	Solanaceae	Dicot
12.	*Brassica oleracea*	Brassicaceae	Dicot
13.	*Brassica napobrassica*	Brassicaceae	Dicot
14.	*Raphanus sativus*	Brassicaceae	Dicot
15.	*Brassica rapa*	Brassicaceae	Dicot

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16.	*Prunus persica*	Rosaceae	Dicot
17.	*Prunus domestica*	Rosaceae	Dicot
18.	*Mallotous philippinensis*	Euphorbaceae	Dicot
19.	*Euphorbia hirta*	Euphorbaceae	Dicot
20.	*Ricinus communis*	Euphorbaceae	Dicot
21.	*Musa accuninata*	Musaceae	Monocot
22.	*Phaseolus vulgaris*	Fabaceae	Dicot
23.	*Pisum saitivum*	Fabaceae	Dicot
24.	*Glycine max*	Fabaceae	Dicot
25.	*Desmodium gangeticum*	Fabaceae	Dicot
26.	*Trifolium repens*	Fabaceae	Dicot
27.	*Citrus aurantium*	Rutaceae	Dicot
28.	*Citrus limonum*	Rutaceae	Dicot
29.	*Murraya koenigii*	Rutaceae	Dicot
30.	*Carica papaya*	Caricaceae	Dicot
31.	*Lantana camara*	Verbinaceae	Dicot
32.	*Clerodendrum viscosum*	Verbinaceae	Dicot
33.	*Parthenium hysterophorus*	Asteraceae	Dicot
34.	*Ageratum conyzoides*	Asteraceae	Dicot
35.	*Xanthium indicum*	Asteraceae	Dicot
36.	*Eupatorium adenophorum*	Asteraceae	Dicot
37.	*Artemisia parviflora*	Asteraceae	Dicot
38.	*Callistemon lanceolatus*	Myrtaceae	Dicot
39.	*Morus alba*	Moraceae	Dicot
40.	*Bougainvillea spp.*	Nyctaginaceae	Dicot
41.	*Saccharum officinarium*	Poaceae	Monocot
42.	*Dendrocalamus giganteus*	Poaceae	Monocot
43.	*Polypogon fugax*	Poaceae	Monocot
44.	*Triticum spp.*	Poaceae	Monocot
45.	*Poaannua*	Poaceae	Monocot
46.	*Cyandon dactylon*	Poaceae	Monocot
47.	*Agave sisalana*	Asparagaceae	Monocot
48.	*Aspergus recemosus*	Asparagaceae	Monocot
49.	*Ocimum sanctum*	Limaceae	Dicot
50.	*Mantha longifolia*	Limaceae	Dicot
51.	*Rheum rhaponticum*	Polygonaceae	Dicot
52.	*Polygonium barbatum*	Polygonaceae	Dicot
53.	*Polygonium hydropiper*	Polygonaceae	Dicot
54.	*Daucus carota*	Apiaceae	Dicot
55.	*Apium graveolens*	Apiaceae	Dicot
56.	*Piper nigrum*	Piperaceae	Dicot
57.	*Vanilla planiflora*	Orchidaceae	Monocot
58.	*Calotropis procera*	Apocynaceae	Dicot
59.	*Thevetia paruviana*	Apocynaceae	Dicot
60.	*Catharanthus roseus*	Apocynaceae	Dicot
61.	*Ipomoea batates*	Convolvolaceae	Dicot

62.	*Ipomoea aquatic*	Convolvolaceae	Dicot
63.	*Ipomoea nil*	Convolvolaceae	Dicot
64.	*Canna indica*	Cannaceae	Monocot
65.	*Chenopodium album*	Amaranthaceae	Dicot
66.	*Amaranthus spinosus*	Amaranthaceae	Dicot
67.	*Pyrostegia venusta*	Binoniaceae	Dicot
68.	*Tecoma castanifolia*	Bignoniaceae	Dicot
69.	*Delphenium denudatum*	Rannunculaceae	Dicot
70.	*Shorea robusta*	Dipterocarpaceae	Dicot
71.	*Cannabis sativa*	Canabaceae	Dicot
72.	*Allium cepa*	Alliaceae	Monocot
73.	*Circuma longa*	Zingiberaceae	Monocot
74.	*Calotropis procera*	Asclpedaceae	Dicot
75.	*Papaver somniferum*	Papaveraceae	Dicot
76.	*Argemone mexicana*	Papaveraceae	Dicot

Table 2: Community 2nd shown the following angiospermic plant species at pH range of 5.5–7.80

S. No.	Botanical name	Family	Division
1	*Eupatorium adenophorum*	Asteraceae	Dicot
2	*Bidens biternata*	Asteraceae	Dicot
3	*Parthenium hystrophorus*	Asteraceae	Dicot
4	*Xanthum indicum*	Asteracaea	Dicot
5	*Ageratum conzoides*	Asteraceae	Dicot
6	*Lantana camara*	Verbinaceae	Dicot
7	*Clerodendrum viscosum*	Verbinaceae	Dicot
8	*Solanum nigrum*	Solanaceae	Dicot
9	*Solanum torvum*	Solanaceae	Dicot
10	*Solanum melongena*	Solanaceae	Dicot
11	*Datura stramonium*	Solanaceae	Dicot
12	*Lycopersicon esculentum*	Solanaceae	Dicot
13	*Achyranthus aspera*	Amaranthaceae	Dicot
14	*Aerva sanguinolenta*	Amaranthaceae	Dicot
15	*Amaranthus spinosus*	Amaranthaceae	Dicot
16	*Chenopodium album*	Chenopodiaceae	Dicot
17	*Cynodon dactylon*	Poaceae	Monocot
18	*Poa annua*	Poaceae	Monocot
19	*Triticum aestivum*	Poaceae	Monocot
21	*Apluda mutica*	Poaceae	Monocot
22	*Pennisetum flaccidum*	Poaceae	Monocot
23	*Saccharum officinarium*	Poaceae	Monocot
24	*Cyperus rotundus*	Cyperaceae	Monocot
25	*Bombax cieba*	Bombacaceae	Dicot
26	*Utrica dioca*	Utricaceae	Dicot
27	*Boehmeria plahyphylla*	Utricaceae	Dicot
28	*Brassica compestris*	Brassicaceae	Dicot

29	*Polygonium hydropiper*	Polygonaceae	Dicot
30	*Polygonium barbatum*	Polygonaceae	Dicot
31	*Rumex hastatus*	Polygonaceae	Dicot
32	*Lepidagathis incurva*	Acanthaceae	Dicot
33	*Adhatoda vasica*	Acanthaceae	Dicot
34	*Sida cordata*	Malvaceae	Dicot
35	*Sida acuta*	Malvaceae	Dicot
36	*Sida rhombiflora*	Malvaceae	Dicot
37	*Sida cordifolia*	Malvaceae	Dicot
39	*Nepeta hindostania*	Lamiaceae	Dicot
40	*Ajuga bracteosa*	Lamiaceae	Dicotf
41	*Ocimum sanctum*	Lamiaceae	Dicot
42	*Ipomoea nil*	Convolvulaceae	Dicot
43	*Booerhaavia diffusa*	Nyctaginaceae	Dicot
44	*Rubus ellipticus*	Rosaceae	Dicot
45	*Fragaria indica*	Rosaceae	Dicot
46	*Dalbaragia sisoo*	Fabaceae	Dicot
47	*Desmodium gangeticum*	Fabaceae	Dicot
48	*Flemingia stroblifera*	Fabaceae	Dicot
49	*Reinwardtia indica*	Linaceae	Dicot
50	*Anagallis arvensis*	Primulaceae	Dicot
51	*Stellaria media*	Caryophyllaceae	Dicot
52	*Oxalis corniculata*	Oxalidaceae	Dicot
53	*Pellucida pepromia*	Piperaceae	Dicot
54	*Mallotus philippensis*	Euphorbaceae	Dicot
55	Ricinus communis	Euphorbaceae	Dicot
56	Jatropha curcas	Euphorbaceae	Dicot
57	Aspergus filicinus	Aspergaceae	Dicot
58	Murraya koenigii	Rutaceae	Dicot
59	Acacia catechu	Mimosaceae	Dicot
60	Carissia opaca	Apocynaceae	Dicot
61	Centella asiatica	Apiaceae	Dicot
61	Salix tetrasperma	Salicaceae	Dicot
62	Randia spinosa	Rubiaceae	Dicot
63	Woodfordia fruticosa	Lythraceae	Dicot
64	Vitis himalayana	Vitaceae	Dicot
65	Ranunculus scleratus	Rannunculaceae	Dicot

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Table 3: Community 3rdshown following angiospermic plant species at a pH range of 5.2–8.20

S. No.	Botanical name	Family	Division
01	*Delphanium denudatum*	Rannunculaceae	Dicot
02	*Clematis Montana*	Rannunculaceae	Dicot
03	*Rannunculus laetus*	Rannunculaceae	Dicot
04	*Rannunculus hirtellus*	Rannunculaceae	Dicot
05	*Berberis asiatica*	Rannunculaceae	Dicot
06	*Schisandra grandiflora*	Schisandraceae	Dicot
07	*Argemone mexicana*	Papaveraceae	Dicot
08	*Stellaria media*	Caryophyllacea	Dicot
09	*Malva neglecta*	Malvaceae	Dicot
10	*Trifolium repens*	Fabaceae	Dicot
11	*Astragalus trichocarpus*	Fabaceae	Dicot
12	*Desmodium multiflorus*	Fabaceae	Dicot
13	*Indigofera heterantha*	Fabaceae	Dicot
14	*Uraria neglecta*	Fabaceae	Dicot
15	*Vicia augustifolia*	Fabaceae	Dicot
16	*Vicia sativa*	Fabaceae	Dicot
17	*Agrimonia pilosa*	Rosaceae	Dicot
18	*Cotoneaster acuminate*	Rosaceae	Dicot
19	*Fragria indica*	Rosaceae	Dicot
20	*Potentillia nepalensis*	Rosaceae	Dicot
21	*Potentillia fulgens*	Rosaceae	Dicot
22	*Prinsepia utilis*	Rosaceae	Dicot
23	*Prunus armeniaca*	Rosaceae	Dicot
24	*Prunus persica*	Rosaceae	Dicot
25	*Pyrus pashia*	Rosaceae	Dicot
26	*Rosa moschata*	Rosaceae	Dicot
27	*Rubus ellipticus*	Rosaceae	Dicot
28	*Rubus paniculatus*	Rosaceae	Dicot
29	*Woodfordia fructicosa*	Lythraceae	Dicot
30	*Punica granatum*	Lythraceae	Dicot
31	*Oenothera rosea*	Onagraceae	Dicot
32	*Hedera nepalensis*	Araliaceae	Dicot
33	*Cornus capitata*	Cornaceae	Dicot
34	*Cornus oblonga*	Cornaceae	Dicot
35	*Abelia triflora*	Linnaeaceae	Dicot
36	*Leptodermis lanceolata*	Rubaceae	Dicot
37	*Rubia cordifolia*	Rubaceae	Dicot
38	*Artemisia parviflora*	Asteraceae	Dicot
39	*Artemisia roxburghiana*	Asteraceae	Dicot
40	*Bidens pilosa*	Asteraceae	Dicot
41	*Anaphalis busua*	Asteraceae	Dicot
42	*Cirsium verutum*	Asteraceae	Dicot
43	*Eupatorium adenophorum*	Asteraceae	Dicot

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44	*Eupatorium riparium*	Asteraceae	Dicot
45	*Inula cappa*	Asteraceae	Dicot
46	*Tagetes minuta*	Asteraceae	Dicot
47	*Taraxacum officinale*	Asteraceae	Dicot
48	*Youngia japonica*	Asteraceae	Dicot
49	*Jasminum grandiflorium*	Oleaceae	Dicot
50	*Solanum xanthocarpum*	Solanaceae	Dicot
51	*Solanum verbascifolim*	Solanaceae	Dicot
52	*Adhatoda vasica*	Acanthaceae	Dicot
53	*Barleria cristata*	Acanthaceae	Dicot
54	*Lantana camara*	Verbinaceae	Dicot
55	*Ajuga bracteosa*	Lamiaceae	Dicot
56	*Ajuga parviflora*	Lamiaceae	Dicot
57	*Salvia lanata*	Lamiaceae	Dicot
58	*Origanum vulgare*	Lamiaceae	Dicot
59	*Plantago major*	Plantaginaceae	Dicot
60	*Cythula tomentosa*	Amaranthaceae	Dicot
61	*Achyranthus aspera*	Amaranthaceae	Dicot
62	*Fagopygon esculentum*	Polygonaceae	Dicot
63	*Polygonum capitatum*	Polygonaceae	Dicot
64	*Polygonum hydropiper*	Polygonaceae	Dicot
65	*Polygonum barbatum*	Polygonaceae	Dicot
66	*Rumex hastatus*	Polygonaceae	Dicot
67	*Populus ciliate*	Salicaceae	Dicot
68	*Salix lindleyana*	Salicaceae	Dicot
69	*Asparagus recemosus*	Asparagaceae	Dicot
70	*Cyperus rotundus*	Cyperaceae	Monocot
71	*Cyanodon dactylon*	Poaceae	Monocot
72	*Vitis himalayana*	Vitaceae	Dicot
73	*Viola serpens*	Violaceae	Dicot
74	*Paris polyphylla*	Melanthiaceae	Monocot
75	*Coriaira nepalensis*	Coriariaceae	Dicot

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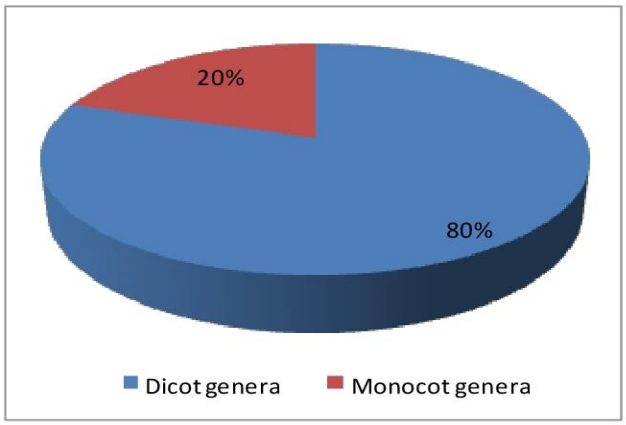

Fig. 1A: Percentage of vegetation under monocot and dicot genera at community 1st of a study area

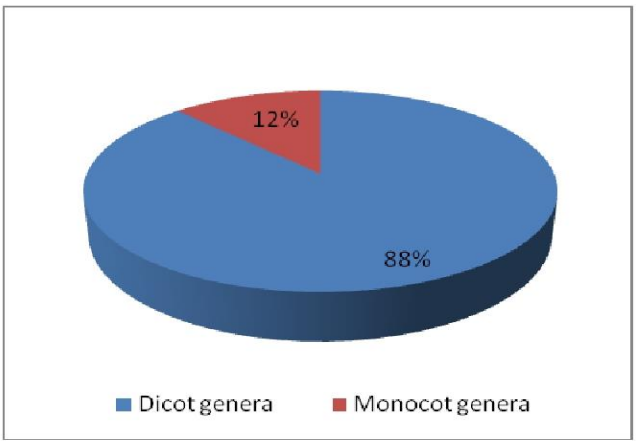

Fig. 1B: Percentage of vegetation under monocot and dicot genera at community 2nd of a study area

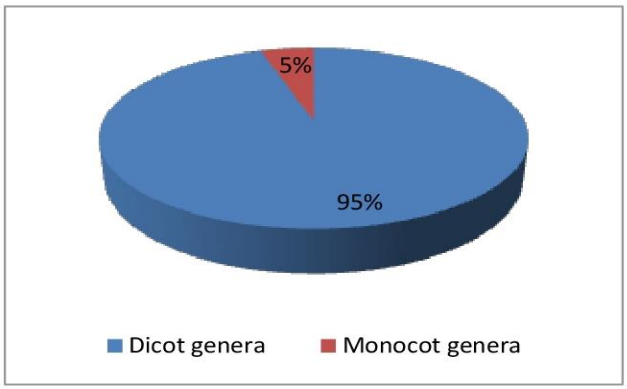

Fig. 1C: Percentage of vegetation under monocot and dicot genera at community 3rd of a study area

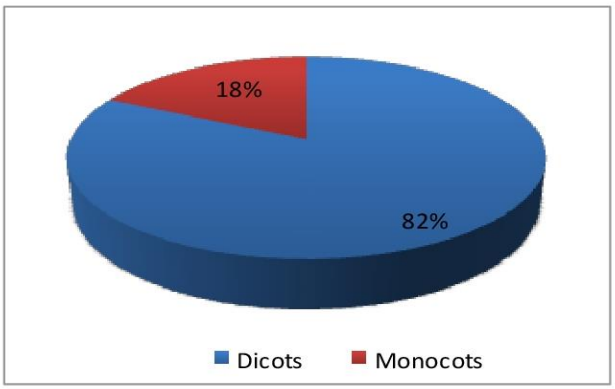

Fig. 2A: Percentage of vegetation under monocot and dicot species at community 1st of a study area

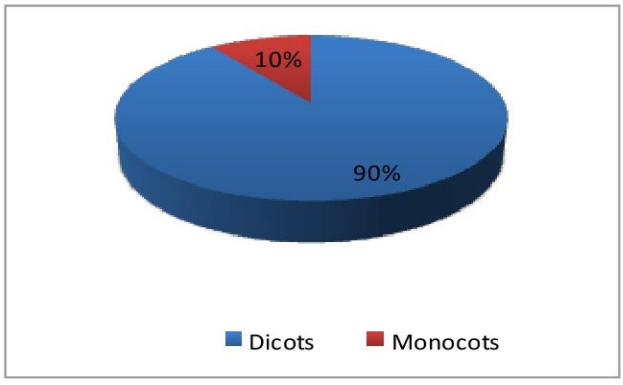

Fig. 2B: Percentage of vegetation under monocot and dicot species at community 2nd of a study area

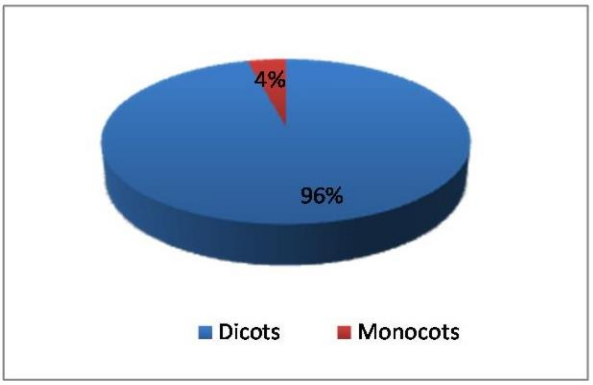

Fig. 2C: Percentage of vegetation under monocot and dicot species ay community 3rd of a study area

DISCUSSION

The present study was conducted in the Doon valley located in the foothills of the Himalayas. It is flourished by a variety of habitats and has unique topography and climatic conditions. The Soil is generally medium loamy but its texture, moisture, and pH generally varies from place to place and with time. The pH of different habitats of Doon valley showed variation and at changing, pH different types of angiospermic families have been observed and documented. Mostly, the pH of the soil was found to be acidic (5.5–6.8).

Due to anthropogenic activities viz. liming, land pollution, increasing traffic, urbanization, and industrialization etc pH of the soil is decreasing and

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seems, it will approach more acidic in the near future. The relation between soil and vegetation has been very important in natural woodland ecosystems. Vegetation once established natural or by human interference modifies soil developmental processes due to parent material, topography, and climate change etc, hence soil and vegetation relation are dynamic.

Sahastradhara and Mussoorie are famous tourist places and mining areas, so highly disturbed by anthropogenic activities. The invasion of *L. camara, P. hysterophorus, E. adenophorum*, and *Ageratum conyzoides* are abundant. The maximum dominance was found to be of *P. hysterophorus* with a mean percentage cover of 15.5 followed by *L. camera* (mean cover 27.9%) [11], but now it had been found that *Lantana* had become a second threat to the western Himalayan forests due to its environmental plasticity as it adjusts bin all types of habitats. In the present study, we observed that the exotic species such as *L. camara*, *P. hysterophorus*, *A. conyzoides, E. adenophorum,* and *Murraya koenigii* etc. have invaded the large area of Doon valley and disturbed the local vegetation to a large extent. The present findings are in agreed with the observations of Odum [7]; Dhyani and Joshi [12].

Variation in soil pH influences the plant growth and is affected by rainfall patterns. When pH reaches a value of 4 or bellows it limits the plant growth. Nutrient availability and microbial activities are favored by a soil pH ranging from 5.5–8.5 as per the studies of Uchida and Hue [13] and Sheik *et al.* [14].

Major factors influencing these changes are edaphic factors which include organic matter, nutrient content, soil pH, and climatic factors which include weather conditions weed competition etc. as per Arya [10]; Hassan and Marwat [15]. Distribution pattern an important aspect of ecological studies showed that all the three communities followed the contagious distribution as per Odum [7]. We found that herbs were the most dominant habit followed by shrubs among all the plant forms follows to Sharma and Joshi [16].

Distribution pattern is an important aspect of ecological studies and in the present study, we found that all the three communities showed contagious distribution, and contagious distribution is the most common type of distribution and it occurs due to little but significant variation in environmental conditions, so in this way our study showed similar results as of Dhayani *et al.* [17].

Therophytes were found to be in high percentage and it is an indication of influences such as grazing [18], and due to anthropogenic activities Manhas [19], which ensures the further invasion of therophytes. It is experienced that vegetation in a stress of biotic pressure gradually increases the percentage of therophytes. It is pertinent to state that the composition of phanerophytes and therophytes is close in this area, an increase in biotic pressure would change the biological spectrum to therophytes and phanerophytes vegetation occurred.

Climate change is a warning call and very well acknowledged threat today. As a result, of climate change unexpected results occur, each species will respond in an individual fashion according to its climate tolerance capacity and its ability to disperse into a new location, and the species which will not adopt will extinct. Rapid climate change favors the adoptability of those species that can tolerate a wide range of climatic conditions. This adaptability has shown by many invasive species in the study area as per the findings of Reshi [20]. Weeds such as *L. camara, P. hysterophorus*, and *A. conyzoides* have invaded and altered the community structure of native flora of the study area as per the findings of Rana [21]; Shigesada [22]. Climate change enhances the dimensions of invasive species to occupy the new areas, by disturbing the dynamic equilibrium maintaining them as per the observations of Walther [23]; Holt *et al.* [24].

Our findings goes parallel to them, we also find similar results of climate change and invasion of species such as *L. camara*, *A. conyzoides*, *P. hysterophorus, E. adenophorum* and *M. koenigii* in abundance. Species diversity and its distribution along the altitudinal gradient has been a major subject of the ecosystem. The diverse altitudinal range and rapid changes in altitudinal gradient at very small distances and high endemism in Garhwal Himalaya make it interesting for studies **[25].** As we move from higher to lower altitude biological diversity increases and vice versa on a mountain in a terrestrial ecosystem as per the findings of Singh and Singh [25].There are many broad ranges in the Garhwal Himalaya (<1500), High altitude specialist genera having mere species such as *Delphinium*, *Ranunculus, Astragalus*, *Saxifraga*, *Sedum, Salix* etc. are most abundant in high altitudes as compared to adjacent low altitudes, as per the findings of Joshi and Joshi [26]; Komar [27].

In the present study, the observation was similar to Arya [10], he stated that soil is mainly black grey and brown in color, and in high elevation, it is of skeletal type. Soil temperature, texture, and pH varied with elevations and proportion of sand 40.7% to 47.2% increased somewhat with the increase in elevation. The present study also suggested that the soil type found in Mussoorie is generally medium loamy but its composition, moisture, and pH generally varied from place to place. Higher silt in Mussoorie was due to higher precipitation in the form of winter snow above 1800 m Soil temperature in Mussoorie ranged from 4^0C–16^0C, while that of Sahastradhara was 15–19^0C. Soil organic matter content tended to be higher in high altitude and increased with increasing altitude respectively.

It was rather difficult to compare the results of the present study with other literatures. There is a need to make correlations between the availability of angiospermic plants with physicochemical and biological variables. The results and findings of the exercise are interpreted in the form of defined relationship between the variables in question and definite risk to climate change in question.

CONCLUSIONS

Geographical factors such as altitudinal variation is a major factor in species distribution, as we move to high altitude there is a decrease in species diversity, as up to an altitude of 5400 m plant growth is restricted. Although, Physico-chemical properties of forest soils vary in space and time because of variation in topography, climate, weathering process, vegetation cover and microbial activities, and several other biotic and abiotic factors Our finding observed that soil temperature in Mussoorie ranged from 4^0C–16^0C, while that of Sahastradhara was 15^0C–19^0C, Sudhowala 15^0C–25^0C. Soil organic matter content tended to be higher in high altitude and increased with increasing altitude. In the present study also stated that pH has a major effect on plant growth and distribution. It affects plant nutrient availability by controlling their chemical forms. The optimum pH range for most of the plants was between 5.5–7, however many plants are adapted to thrive at pH slightly above or below this range but when pH level falls to 4 it limits plant growth finally, we can say that ideal pH range for plant growth was between 6.0-8 and pH below 5.6 isn't suitable for proper growth of the plant.

There are several ways to rise and decrease soil pH, hence in the light of the lack of literature, it is rather difficult to compare the results of the present study with others. There is a need to make correlations between the availability of angiospermic plants with physicochemical and biological variables.

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