Floral diversity of abandoned mansions and the influence of soil properties on these unique vegetations.

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Abstract

The findings of this research will give a better understanding about soil-plant interaction and will reveal a new area in bioscience to develop new technologies regarding in situ plant species conservation.

Introduction

Land is a fundamental element for the survival of human on earth. Construction & agriculture are totally dependent on the availability of suitable land. During the early civilization era, a large amount of land was come under agriculture by deforestation[1-2]. But in the recent past centuries, a retrogressive situation has been observed. Due to the migration of rural people to the urban areas in search of livelihood, many farmlands were abandoned throughout the world, particularly in Europe[3-5]. The process is still so pronounced that researches predict, it will be continued for next few decades[6-8]. Around 210 million hectare farmland area had been abandoned in Europe, North America and Oceania till 1990, with the most critical condition in Europe where abandoned areas comprised of one-third of the total arable land[9-10]. Land abandonment is one kind of ecological restoration process that transforms cultivated land into wild vegetion[11].

In recent years, there were few works carried out on abandonend areas in Asia by researchers. Due to low public access, wild flora and fauna get sufficient opportunities to flourish in these region .Though these areas are much rich in species diversity as compared to the farm and fellow lands, very few researches have conducted on them to evaluate their floral richness. Moreover, none of the researches have concluded any finding to reveal the exact reasons behind the plant species diversity in these regions. Passive re-vegetation in permanently abandoned an adorable land (called secondary succession) is characterized by the re-placement species of a variety of habitat species of habitat dispersed species of habitat shapes[12]. Such secondary succession initially starts with annual or biannual plants, is then followed by perennial forbs, grasses and shrubs, and finally under usual Central European conditions ending up in a forest (climax stage). Abandonment of agricultural land is a significant change in land use from cultivation to a complex of plant successions. In most of Europe, the vegetation of deserted farmland has evolved into a dense forest or shrub. The expansion of vegetation explains, in part, the perceived decline in water resources, reductions in soil loss, and the progressive improvement of soil characteristics[5]. Determination of species richness of an area is essential to measure its importance in biodiversity conservation[13]. There are a number of diversity indexes exist which are used as bioindicators in studies on both aquatic and terrestrial ecosystems[14]. A comprehensive list of all living organisms of an area along with their present conservation status and future improvement plan is essential to conserve and maintain biodiversity in a wild region. Continuous monitoring on wild ecosystems have a significant impact on national biodiversity assessment[15]. Floral diversity of an area plays a vital role on soil microclimate modification and nutrient recycling[16]. The interrelationship between soil and plant has been considered as a major mystery of nature and investigated by different researchers[17-20].

Biodiversity has developed as a complex concept recently. Plant biodiversity is an obscure understanding that represents heterogeneity and wide variations.Studies of plant variety have shown that secondary succession patterns depend upon the species that are initially present, their persistence or extinction and on the organization of latest species from native or regional species pools[21]. Similar patterns in secondary succession may be expected for soil organizations. However, spatial and temporal scales of spreading and formation take issue between plant and soil organisms similarly as between phyletic cluster of soil organisms. This could end in totally different national diversity patterns for plants and soil organization. A stronger understanding of the mechanism that drive soil diversity patterns will increased our understanding of the relationships between plant diversity and soil.

But it seems to be different for each plant species[22]. The pattern of plant distribution & dynamics of biological resources determine the rational design and choice development of plant succession pathways within an ecosystem[23]. Introducing a new species without maintaining this manner may cause severe anomaly to its natural surroundings[24]. Explanation of vegetion type, composition of species, comment or prediction on the classification and pattern of vegetations in a purposeful manner are the basic objectives of phytosociology[25]. It is the study of distribution, composition, classification and interrelationship of plant communities[26]. The pattern and classification of plant communities within an ecosystem is regarded as phytosociology[25, 27]. It is a very useful tool to track changes in vegetion composition and how it alters edaphic components. Succession of plant species & their interactions are affected by several abiotic variables like soil texture, moisture, availability of nutrients, temperture, exposure to light and wind etc. Phytosociological study is regarded as the most advanced and economical method to exploit useful plant species from natural habitats[28].

Due to the balanced progression of plant succession and soil erosion, a wide range of environments occur in the abandoned regions simultaneously[5, 29]. If the environmental factors remain favourable for plant communities, development of forest ecosystem can occur within a short period of time. Land abandonment has several benefits including i) expansion of vegetion cover that recovers the damaged ecosystem caused by deforestation[30, 31]; ii) higher absorption rate of carbon dioxide (CO_2) which is the main culprit for global warming[32]; iii) increase of vegetion diversity during the secondary succession of plant species[33-36]; iv) improvement of water infiltration and interception that reduces the chance of flooding[37, 38]; v) better regulation of water cycle within the area that reduces soil erosion and ensures high quality runoff[5, 39]; vi) promotes higher longevity of adjacent reservoirs as it renders sediment contribution by discontinuing sediment transport network and protecting the soil surface from direct splash[40, 41]. As the plant taxonomy and ecology has a prominent importance in different conservation programs, the present research was conducted with the following objectives: (a) analysis of phytosociological attributes of some abandoned mansions' natural vegetations and (b) assessment of the interrelationship between floral diversity and soil physico-chemical properties within the abandoned sites.

Result

Phytosociological analysis of plant species in abandoned land of krittipasa (study site-1), Duttapara (study site-2) and Lakutia (study site-3)

The plant species survey at the site-1 recorded 46 species under 29 families.In Duttapara (study site-2), 48 plant species under 32 families were recorded.A total 28 plant species under 22 families were recorded in Lakutia (Study site-3).

Density and Relative Density : The most densely populated populated species at site-1 (Table 4) were *Vernonia cinerea* (density of 10.25 and relative density of 9.601) followed by *Chromolaena odorata* (density of 9.74 and relative density of 9.134), *Ardisia solanacea* (density of 8 and relative density of 7.495), *Mikania micrantha* (density of 6.25 and relative density of 5.855), *Alocasia acuminata* (density of 5.75 and relative density of 5.387), *Glycosmis pentaphylla* (density of 5.5 and relative density of 5.152). *Spathodea campanulata* and *Ficus benghalensis* exhibited least density and relative density (0.25 and 0.234) followed by *Alstonia scholaris, Borassus flabellifer.*

On the other hand at site-2 (Table 5) *piper longum* was most densely populated species (density of 9 and relative density of 9) followed by *Adiantum philippense* (density of 8.75 and relative density of 8.57), *Mikania micrantha* (density of 7 and relative density of 6.86), *Achyranthes aspera* (density of 6 and relative density of 5.88%) and *Phyllanthus niruri* (density of 5.5 and relative density of 5.39). *Ficus racemosa* and *Nyctanthes arbor-tristis* exhibited least density and relative density (0.25 and 0.24) followed by *Carica papaya, Diospyros malabarica, Calamus tenuis* and *Citrus maxima.*

Site-3 (Table 6) represents that most densely populated species were *Pteris vittata* (density of 2.5 and relative density of 2.04) and *Clerodendrum viscosum* (density of 2 and relative density of 2 and relative density of 1.64) followed by *Solanum indicum* (density of 2 and relative density of 1.64), *Lepidagathis linearis* (density of 1.75 and relative density of 1.43), *Synedrella nodifilia* (density of 1.75 and relative density of 1.43) and *Urtica nivea* (density of 2 and relative density of 1.43). *Scoparia dulchis* exhibited least density and relative density (0.25 and 0.20) followed by *Persicaria lapathifolia, Passiflora foetida, Morinda citrifolia* and *Solanum torvum*.

Frequency and Relative Frequency: The most frequent species at site-1 (Table 4) was *Alocasia acuminata* (frequency of 77.77 and relative frequency of 7.29) followed by *Ardisia solanacea* (frequency of 66.66 and relative frequency of 6.25), *Chromolaena odorota* (frquency of 55.55 and relative frequency of 5.20), *Mikania micrantha* (frequency of 55.55 and relative frequency of 5.20) and *Glycosmis pentaphylla* (frequency of 55.55 and relative frequency of 5.20). Percentage of frequency and relative frequency as (11.11 and 1.04) exhibited by most of species followed by *Sida acuta, Oxalis corniculata, Ageratum conyzoides, Centella asiatica, Solanum indicum, Adiantum tenerum, Christella dentata, Ficus benghalensis, Alastonia scholaris, Ficus rumphii, Borassus flabellifer, Cyperus rotundus, Xanthosoma violaceum, Cayratia trifolia, Smilax macrophylla, Calophyllum inophyllum, Ficus microcarpa* and *Ardisia humilis.*

On the other hand at site-2 (Table 5) was *Mikania micrantha* (frequency of 66.66 and relative frequency of 7.68) followed by *Ficus hispida* (frequency of 50 and relative frequency of 5.77), *Ficus benghalensis* (frequency of 33.33 and relative frequency of 3.84), *Alocasia acuminata* (frquency of 33.33 and relative frequency of 3.84), *Achyranthes aspera* (frequency of 33.33 and relative frequency 3.84), *Stachytarpheta jamaicensis* (frequency of. 33.33 and relative frequency of 3.84), *Aphanamixis polystachya* (frequency of 33.33 and relative frequency of 3.84), *Glycosmis triphylla* (frequency of 33.33 and relative frequency of 3.84) and *Tiliacora acuminata* (frequency of 33.33 and relative frequency of 3.84). Percentage of frquency and relative frequency as (16.66 and 1.92) was exhibited by most of species followed by *Operculina turpethum, Bryophullum pinnatum, Phyllanthus reticulatus, Commelina benghalensis, Ficus racemosa, Clerodendrum viscosum, Cassia fistula,Phyllanthus niruri,Breynia vitis-idaea, Urena lobata,Curcuma longa,Oxalis corniculata, Xanthosoma violaceum, Crinum asiaticum, Carica papaya, Syzygium fruticosum, Diospyros malabarica, Turnea ulmifolia, Nyctanthes arbor-tristis, Dioscorea pentaphylla, Adiantum capillus-veneris, Dioscorea esculenta, Piper longum,Ardisia solanacea, Vitex negundo, Curcuma zedoaria, Zehneria japonica, Urginea indica,Adiantum philippense, Glycosmis pentaphylla, Ardisia humilis, Paperomia pellucida, Drynaria quercifolia, Microsorum punctatum, Musa acuminata, Calamus tenuis, Colocasia esculenta, Clinogyne dichotoma, Citrus maxima.*

At site-3 (Table 6) the most frequent species was *Sloanum indicum* (frequency of 100 and relative frequency of 8) followed by *Artocarpus heterophyllus* (frequency of 75 and relative frequency of 6), *Pteris vittata* (frequency of 75 and relative frequency of 6) and *Lepidagathis linearis* (frequency of 75 and relative frequency of 6). Percentage of frequency and relative frequency as (50 and 4) exhibited by most of species followed by *Albizia richardiana, Urtica nivea, Dioscorea alata,Oxalis corniculata, Tabernaemontana divaricata, Synedrella nodiflora,Desmodium gangeticum, Nyctanthes arbor-tristis, Rungia pectinata, Nephrolepis cordifolia, Alstonia scholaris, Capparis zeylanica, Clerodendrum viscosum* respectively.

Abundance: The most abundant species at site-1 (Table 4) was *Vernonia cinerea* with an abundance of 13.66 followed by *Piper longum* and *Ageratum conyzoides* with an abundance of 10 each. On the other hand at site-2 (Table 5) the most abundant species was *piper longum* with an abundance of 36 followed by *Adiantum philippense* (35), *Phyllanthus niruri* (22) and *Phyllanthus reticulatus* (21) respectively. At site-3 (Table 2) most abundant Species were exhibited by *Mikania micrantha, Clerodendrum viscosum, Piper longum, Ardisia solanacea, Glycosmis triphylla*.

Relative Dominance: The highest relative dominance was occupied by *Clerodendrum viscosum, Mikania micrantha, Glycosmis pentaphylla, Polyalthia suberosa, Mikania cordata, Ficus hispida and Ficus religiosa* respectively. The lowest relative dominance were represented by *Pothos scandens, Piper longum, Ardisia humilis* and *Adiantum tenerum* respectively. Site-2 (Table 5) represents that highest relative dominance was occupied by *Mikania micrantha, Cassia fistulosa, Clerodendrum viscosum, Phyllanthus niruri, Ficus hispida* and *Ficus benghalensis* respectively. The lowest relative dominance were represented by *Drynaria quercifolia, Curcuma longa, Zehneria japonica, Paperomia pellucida, Xanthosoma violaceum* respectively. On the other hand, Site-3 (Table 5) highet relative dominance were exhibited by *Microlepia speluncae, Albizia richardiana, Solanum indicum, Tabernaemontana divaricata, Clerodendrum viscosum, Alastonia scholaris, Glycolysis triphylla* and *Artocarpus heterophyllus* respectively.

Distribution : The maximum value of distribution were exhibited by *Piper longum* (.90), *Ardisia humilis* (.63), *Centella asiatica* (.54), *Oxalis corniculat*a (.54), *Stephania japonica* (.45) and *Calophyllum inophyllum* and least distribution were exhibited by *Alocasia acuminata, Ficus virens, Morinda citrifolia* at site-2 (Table 4). *Piper longum* exhibited maximum value of distribution at site-2 followed by *Adiantum philippense, Phyllanthus niruri* and *Phyllanthus reticulatus*. Lowest distribution were represented by *Ardisia humilis, Ficus benghalensis, Ficus racemosa, Diospyros malabarica, Carica papaya, Nyctanthes arbor-tristis, calamus tenuis* and *citrus maxima*. On the other hand at site-3 maximum value of distribution occupied by *Glycosmis triphylla, Ardisia solanacea* and *Microlepia speluncae* and the lowest values represented by *Artocarpus heterophyllus* and *Solanum indicum.*

Important Value Index (IVI) : IVI was the highest for *Clerodendrum viscosum* as 39.66 (at site-1)followed by *Mikania micrantha* as 26.05, *Glycosmis pentaphylla* as 23.36, *Chromolaena odorata* as 16.99, *Polyalthia suberosa* as 14.49, *Ardisia solanacea* as 14.21, *Vernonia cinerea* as 13.18, *Alocasia acuminata* as 13.14 respectively. IVI were obtained highet for *Mikania micrantha* as 29.94, *Cassia fistulosa* as 26.77, *Phyllanthus niruri* as 16, *Clerodendrum viscosum* as 13.56, *Ficus hispida* 13.18, *Piper longum* as 12.56, *Achyranthes aspera* as 10.87 respectively (Table 5). On the other hand at site 3 IVI was the highest represented by *Sloanum indicum* (22.59), *Albizia richardiana* (19.03), *Microlepia speluncae* (18.72), *Tabernaemontana divaricata* (16.58), *Clerodendrum viscosum* (14.99) and *Alstonia scholaris* (11.77) respectively.

Preparation of frequency diagram

Raunkiaer (1934) recognized five frequency classes of plant species in the community on the of their frequency percentages. These are as follows:

Class A-1 to 20% frequency

Class B-21 to 40% frequency

Class C-41 to 60 % frequency

Class D -61 to 80% frequency

Class E-81 to 100% frequency

The frequency values refers to the values of Raunkier's formula: A>B>C>D (site -1), A>B>C= D (site-2) and B<C>D>A (Site-3), (Table 10). The present ecological study shows that the given vegetation is heterogenous in nature.

Fig. 2 shows that more shrubs (38.93%), climber (16.10%) available at site 1. A lot of herbs (60.5%) were found at site-2 and at site-3 the highest tree percentage (11.38%) in comparison to the other study areas was observed.

Abundance of plant families There were in total 30 families found at the site-1(Fig. 1a), 31 families were also found at site-2 (Fig. 1b) and 21 families at the site-3 (Fig. 1c)

Species Diversity & Distribution

Diversity and Dominance of species at site-1(Fig. 6a, Fig. 4a): A total of 46 plant species with (H= 3.47) diversity value were recorded at site-1. The maximum IVI distribution analysis of the plant species of abandoned land showed that the dominant was *Clerodendrum viscosum.* The co-dominant species were *Mikania micrantha, Glycosmis pentaphylla, Chromolaena odorata*, *Polyalthia suberosa, Ardisia solanacea, Vernonia cinerea, Alocasia acuminata* respectively (Table 1).

Diversity and Dominance of species at site-2 (Fig. 6b, Fig. 4b): A total of 48 plant species with (H= 3.20) diversity value were recorded at site-3. The maximum IVI distribution analysis of the plant species of abandoned land showed that the dominant was *Mikania micrantha.* The co- dominant species were *Cassia fistulosa, Phyllanthus niruri, Clerodendrum viscosum, Ficus hispida, Piper longum, Achyranthes aspera* respectively (Table-2).

Diversity and Dominance of species at site-3 (Fig. 6c, Fig. 4c): A total of 48 plant species with (H= 2.45) diversity value were recorded at site-3. The maximum IVI distribution analysis of the plant species of abandoned land showed that the dominant was *Sloanum indicum.* The co-dominant species were *Albizia richardiana, Microlepia speluncae, Tabernaemontana divaricata, Clerodendrum viscosum* and *Alstonia scholaris* respectively (Table 3).

Species Richness: The species rarefaction curve of the species richness was found to be higher in the quadrat-5 followed by q9, q8 at site-1 (Fig. 5a). However, the trends of species rchness were found to be greater in the quadrat-1 followed by q4, q3 at site-2 (Fig. 5b)and species richness also found higher at q1 at site-3 (Fig. 5c).

Ecological characterization

Soil properties: Within the three study sites, sandy loam and sandy clay loam type soils were prominent. Usually these soil types have high fertility and provide suitable environment for different insects and micro-organisms.

Fig. 7 shows that in these three study areas, reddish brown coloured soil was predominant followed by blackish brown and light brown soils. In some reddish brown soil samples, small granules of concrete were found which limited the establishment of higher plants as evidenced by the absence of plant roots. Soils from lower areas were blackish, heavy and clayey.

Soil Colour: Fig. 7 shows that in these three study areas, reddish brown coloured soil was predominant followed by blackish brown and light brown soils. In some reddish brown soil samples, small granules of concrete were found which limited the establishment of higher plants as evidenced by the absence of plant roots. Soils from lower areas were blackish, heavy and clayey.

Soil physico-chemical attributes

pH: The pH of all soil samples were found to be ranged in between 7.4 to 8.1 (for site-1), 7.1 to 7.7 (site-2), 7.2 to 7.6 (site-3) within average value 7.8, 7.43, 7.44 respectively. The lowest value (7.1) was observed at the quadrat no. 01 within site-2 and the highest value was (8.1) at quadrat no. 09, 05 within site-1 (Table 7).

Salinity (EC): Values of soil electrical conductivity ranged largely between the lowest 0.59 and the highest 2.04 dS/m at site-1, 0.60 to 2.23 dS/m at site-2 and 0.88 to 2.20 dS/m site-3 within mean values 1.0, 1.34, 1.40 dS/m.

Organic matter: Percentage of organic matter of all soil samples were found to be ranged between 0.30 to 13.39 % with the average value 3.05 % (at site-1), 2.00 to 12.00% with the average value 8.40% (site-2), (Table 8). 4.23 to 13.00% with average value 9.78 % (site-3).

Nitrogen : It was observed that percentage of total nitrogen of the soil samples were 0.015 to 0.699% within average value 0.15% (at site-1), 0.100 to 0.600% wihin average value 0.42% (site-2) and 0.100 to 0.600% within average value 0.23 % (site-3), (Table 9).

Potassium : The potassium (K) concentration of the soil samples were 0.28 to 1.00 meq /100 g soil (at site-1), 0.56 to 1.14 meq/100 g soil (site-2) and 0.55 to 1.10 meq/100 g soil (site-3) within mean values 0.85, 0.81 and 0.57 meqt /100 g soil.

Phophorus: The highest concentration (84.7μ g/g soil) of phophorus was observed at quadrat no.08 at site-1 within average value of 27.9 g/g (Table 7). The lowest concentration (2.5 μg/g) of phophorus also observed at quadrat no.05 at site-2 (Table 8) within average value of 20.7 μg/ g soil. It was observed that concentration of total phophorus at site-3 were 2.8 to 25.8 μg/g soil with in average value 11.7 g/ g soil (Table 9).

Moisture: Present study showed that percentage of moisture of all soil samples were 10.2 to 37.45% within average value 11.84 % (at site-1), 20.6 to 35.3% within average value 27.6 % (site-2) and 12.29 to 17.20% within average value 14.86% (site-3).

Heirarchical cluster of the species based on the dominance of the species

In order to determine the dominance of the tree species, produced the hieriachial cluster.Figure shows that rcorded species in abandoned land of three different site. *Clerodendrum viscosum* are most dominant species which are the member of first cluster and rest of the species (*Alocasia acuminata, Chromolaena* *odorata, Ardisia solanacea* and *Vernonia cinerea*) were co-dominating species at site-1.The rest of species form 2nd, 3rd, 4th, 5th cluster (Fig. 8a).

At site-2, Figure shows that recorded species produced species hierarchial cluster. *Mikania micrantha* and *Cassia fistula* are most dominant species which are the member of first cluster and rest of species form 2nd, 3rd, 4th and 5th cluster (Fig. 8b). On the other hand, at site-3 *Solanum indicum* and *Clerodendrum viscosum* are most dominant within member of first cluster (Fig. 8c). *Microlepia speluncae, Albizia richardiana* and *Tabernae-montana divaricata* form the second dominant cluster of species in the study site-3. All these species are of natural origin. This signifies the importance of the abandoned land for native tree diversity conservation.

Relationship between vegetation spatial distribution and environmental factor

RDA was used to analyze the relationship between the soil factors and abandoned land vegetation distribution in Barishal. Biplot score of the plant species derived from RDA analysis where soil properties were used as environmental variable shown in Fig. 9a, 9b, 9c respectively.

Relationship between vegetation and soil factors at site-1.

RDA analysis showed that soil moisture, electric conductivity, potassium, organic matter, nitrogen, phosphorus and pH were significantly correlated with species data at site-1 (Fig. 9a). *Ardidisia solanacea, Alocasia acuminata* showed significant correlation with soil potassium. The distribution of *Laportea interrupta, Ageratum conyzoides, Centella asiatica, Adiantum Philippense* was mainly affected by soil pH and electric conductivity. The distribution of *Mikania micrantha, Ipomoea hederifolia* was mainly affected by soil moisture. *Pteris vittata, Phyllanthus reticulatus, Xanthosoma violaceum* and *Calophyllum inophyllum* showed significant correlation with soil organic matter, phosphorus and Nitrogen.

Relationship between vegetation and soil factors at site-2.

The distribution of *Phyllanthus niruri, Cassia fistula, Achyranthes aspera, Mikania micrantha, Clerodendrum viscosum, Alocasia acuminata, Phyllanthus reticulatus, Stachytarpheta jamaicensis* and *Ficus hispida* mainly affected with soil electric conductivity, organic matter, nitrogen and potassium (Fig. 9b).

Relationship between vegetation and soil factors at site-3.

The distribution of *Clerodendrum viscosum, Dioscorea alata, Urtica nivea* and *Microlepia speluncae* was mainly affected by soil organic matter*. Synedrella nodifolia, Desmodium gangeticum* and *Piper longum* showed significant correlation with soil electric conductivity. The distribution of *Rungia pectinata* was mainly affected by soil pH (Fig. 9c).

Discussion

Phytosociology is the branch of science which deals with plant communities, their composition and development, and therefore the relations between species. The structure of a community is set chiefly by the dominant plant species and not by different characteristics[25]. All of these species don't seem to be equally necessary however there are solely a couple of overtopping species that by their bulk and growth modify the home ground and management the expansion of different species of the community as these species are known as dominants[42]. The current analysis is an attempt to assess composition, structure and diversity of plant species in abandoned land. The research analysis of information revealed that most herb species were recorded from the study sites. There were in total thirty families found at the site-1 (Fig. 1a), family of Moraceae possessed the highest number of species followed by Asteraceae and Araceae.There are also thirty families were also found at site-2 (Fig. 1b) and family of Verbanaceae possessed highest number of species followed by Moraceae, Euphorbiaceae and 21 families at the site 3 (Fig. 1c). Family Verbenaceae, Acanthaceae, Apocynaceae, Mimosaceae and Rutaceae possessed highest number of species. Analysis of IVI provides data concerning the status of a species and may be recognized as patterns of association of dominant species during a community[43]. Throughout the present study it had been found that each one of the 3 sites were dominated by Clerodendrum viscosum, Mikania micrantha, Solanum indicum with the utmost IVI value. It's dominance at the particular sites was preably on account of awareness of optimum conditions for its growth.Higher IVI of a species confers dominance over a vegetation by that species and plants having low IVI are entangled by the dominating ones. However, every species in a plant community has a specific role and there is always a qualitative interrelationship present between the rare and abundant species[44]. Sorenson constant (S) value of the three survey regions was 0.0245 which indicates that there was only about 2.5% similarity present regarding their species composition. Diversity means number of species, their richness, abundance, spatial and temporal variations within an ecosystem. When a large number of plant species occurs in a restricted region with high richness and evenness values, it demonstrated that the vegetation flourishes under favourable environment[45]. In site-1, Moraceae was the most dominant family in terms of species number. This family comprises of about fourty genera and well-stablished in the tropical Old World[46, 47]. Evidences from molecular and morphological studies ensure that it is a monophyletic family[48-50]. The second most dominating plant families were Asteraceae and Araceae. Members of the Asteraceae family comprised of different growth forms that allow them to dominate during the primary stages of plant succession. Usually plants under Araceae family possess a compact covering near the ground level and fashioned like short umbrella with well-defined petioles[51]. Members of the Araceae family were widespread throughout the world during the Cretaceous[52-59]. Most of them are still dominant in the tropical regions along with some subtropical and temperate regions' representatives. Divergent evolution among the enclosed representatives were confirmed by molecular and morphological analyses[60, 61].

Family of family Verbenaceae emerged as dominant species at site-3. This may be as a results of (Verbenaceae) includes the following ingredients: (1) spreading of seeds for long distances by several native and introduced birds; (2) toxicity of its fruit for several mammals, that limits damage by herbivore; (3) its ability to sprout smartly following harm (e.g., by trampling); (4) its ability to invade a wide range of habitats; (5) production of allopathic substances, that improves its competitive ability; and (6) its ability to flower copiously for long periods, therefore attracting pollinators and making certain copious seed set. Species richness generally will increase throughout secondary succession once environmental and edaphic conditions area unit favorable with low fluctuations[63].

The quantitative relationship between abundance and frequency (A/F) indicated the contiguous distribution of plant species rather than regular distribution. Perhaps, contiguous distribution pattern is a notable characteristic of natural ecosystems[25, 44, 62-67]. Uniform environment usually supports regular distribution pattern of species while contiguous distribution pattern occurs in a place where a severe competition for resources exists. Though in a such competition, plant species prefer vegetative reproduction over sexuality, they can't solely depend on vegetative multiplication as there are multiple factors present regarding new generation establishment[65].

. Patterns of distribution rely both on physico-chemical nature of the environment and the biological peculiarities of the organisms[25]. The study site shows that more shrubs (38.93%), climber (16.10%) available at site 1. A lot of herbs (60.5%) were found at site 2. A low density of woody species has been shown to improve soil nutrient status and thus develop grass-growing conditions[68, 69].

Diversity indexes provide valuable information regarding the composition and quality of vegetation in a study area and thus ultimately helps us to understand the community structure of a natural ecosystem. The values of Shannon-Wieners diversity index of the three sites were 3.47, 3.20 and 2.45 respectively which indicates that these are relatively diversity rich area as the values laid between 1.5 to 3.5 range[53]. The values of Simpson's diversity index were also found extremely high as 0.99, 0.99 and 0.96 respectively (Fig. 3) which means if we take two plant samples randomly from two different quadrats, there are at least 96% chance that the samples we choose are two different species[54]. The Margalef's Richness Index (7.43, 7.82, 5.62) and Menhinick's Richness Index (2.23, 2.38, 2.53) of the three study sites (Fig. 3) reflect their high species richness. The Pielou's Evenness Index values were 0.26, 0.83 and 0.88 respectively for the study sites (Fig. 3) which indicate that the continuity of vegetation varies significantly from one place to another. However, all these values were considerably higher than that obtained from different studies on the natural forests of Bangladesh[70-76]. One of the probable reasons behind this phenomenon is that, natural forests are well-stablished ecosystem sustaining over a long time while vegetations of abandoned mansions are comparatively recent establishments via secondary succession of plant species. Thus, there are a large number of competitor species gather to run a struggle for existence and ensure survival of the fittest on that territory. There is a part of society which gives positive response to conserve abandoned lands, which assists these locations to achieve aesthetic look[77-79].

Natural forest conservation requires authentic and consistent information on species composition and diversity pattern. Multivariate statistical methods including clustering of species are well developed in vegetation ecology[80-82]. Hierarchial cluster of the species based on dominance of the species shown Solanum indicum, Tabernaemontana divaricata, Albizia richardiana, Mikania micrantha, Cassia fistula, Clerodendrum viscosum were most dominant. All these species are of natural origin. Plant species found in this study are of natural origin, which indicates the importance of indigenous plant species conservation in abandoned land ecosystem. Abandoned land increase in natural vegetation provides aesthetic values[77-79.]

The pH of all soil samples was found to be ranged in between 7.4 to 8.1 (for site -1), 7.1 to 7.7 (site-2), 7.2 to 7.6 (site-3) within average value 7.8, 7.43, 7.44 respectively which indicates slightly alkaline soil. In most cases, pH range of 6.0-7.5 is optimum for the adequate availability of nutrients in the soil[83]. Values of EC ranged largely between the lowest one 0.59 and the highest 2.04 dS/m at site-1, 0.60 to 2.23 dS/m at site-2 and 0.88 to 2.20 dS/m site-3 within mean values 1.0, 1.34, 1.40 dS/m.Soil EC values range from 0-2 dS/ m indicates non saline soil[84]. Percentage of organic matter of all soil samples in mean values 3.05% (site-1), 8.40% (site-2) and 9.78% (site-3), respectively. High (>3.4%) soil organic matter status indicates suitable for crop production[83]. It was observed that percentage of total nitrogen of the soil samples within average values 0.15% (site-1), 0.42% (site-2) and 0.23% (site-3). It indicates that all nitrogen status were nearly to optimum (0.271 to 0.36%) level. Mean Phosphorus status were 27.9µg/g (site-1), 20.7 µg/g (site-2), and 11.7 µg/g (site-3) respectively. All the P status except site-1 indicates were lower than optimum (22.51 to 18.1 µg/g soil) level. Potassium status within mean values 0.85, 0.81 and 0.57 meq/100g soil at site-1, site-2 and site-3 respectively. Mean K status indicates were higher than the optimum level[83].

The relationship of vegetation to environmental soil factors assessed using RDA ordinations. The variability of physical and chemical soil properties across sites indicates that abandoned terrestrial vegetation is not uniform in the vicinity. The soils associated with vegetation constitute the most remarkable resources in the ecosystem. Quantification of variation in species diversity and community composition as a function of their location resulted in inferring effective mechanisms for assembling plant communities[85-87]. Similar results were observed in lowlands, temperate forests, dry prairies, beech forests and natural forests[88-89]. We also found that the most factors touching vegetation distribution were soil organic matter, conductivity, pH, total N, phosphorus and moisture provides nutrients to plant ensures plant production and development and plays a very important role within the property development of the land.

Soil pH has a prominent role in determining physical properties and fertility of soil, which have direct effect on plant growth[90]. Soil pH determines the productivity of soil and separation of the plant clusters growth[91]. Direct effects of the soil pH can be confirmed via plant forms, nutrient metabolism, growth, quality and quantity of yield, while indirect effects can be observed by the impact of physical, chemical and biological properties of soil on vegetation development[92, 93]. Phosphorus has a key role in plant nutrition and hence the concentration and availability of P is responsible for the fertility and productivity of soil to a great extent as P is needed by plants in a comparatively large amount.Phosphorus with the distribution of plant species in northeast America[94] while it was the most common problem in plant communities in Brazil[95]. The nutrients generally contend a serious role within the classification of plant cluster. Phosphorus within the soil will be absorbed by the plant component; several different studies have noted the role of available phosphorus within the distribution pattern of plant communities[96,97]. In soil-vegetation systems, soil and vegetation are interact to one another. Soil affects vegetation and restricts soil[98,99]. The results not only showed that the soil factors contend a very important role within the vegetation community succession method, but also additionally discovered that the vegetation community contend a very important role in soil restoration and reconstruction

Spatial distribution and aggregation of plant communities were affected by their dynamic state and spatial heterogeneity to a great extent during this process[100, 101]. We mainly focused on the interaction between the distribution pattern of plant communities and the physico-chemical properties of soil with some relatively remarkable effects of this interaction on population dynamics.

Conclusion And Recommendation

This study gives us insight into the floral richness hidden inside the abandoned mansions that have never been explored before. If these vegetation's are kept outside from human exploitation for a longer time, their soil will get more chances to be fortified with organic matter and will flourish with more plant species over time. By implementing the knowledge of soil-plant interaction discovered in the present study, in-situ conservation can be improvised to save a large amount of germplasm within a limited area. Moreover, these sites can be studied as a model ecosystem because of secondary succession of plant species in human intervened regions. Data obtained from this survey can also be utilized efficiently to develop new technologies regarding ex-situ conservation of plant species in botanical gardens to cope up with other modern conservation strategies.

Materials And Methods

Selection of the study sites

The study was planned to be meted out within the following areas of Bangladesh in Barisal division- Kritipasa abandoned land, Duttapara abandoned land and Lakutia abandoned land. It's been chosen, as a result of those 3 area unit as are acknowledge for his or her sensible natural forest condition, vegetation conservation activities:- Kritipasa (site-1), Duttapara (site-2), Lakutia (site-3).

Kritipasa abandoned land

Kritipasa was named when king krity Narayan. Ramjibonsen based the kritipasapalace. Kritipasa abandoned land is found at the village Kritipasa of Jhalokhati district. This can be most likely a century recent house. Now a days, it's abandoned and in an exceedingly ramshackle conditiom. The zamindarbari (landlord's house) five kilometers northwest of Jhalakhati.

Climate: The typical annual temperature is 26.0°C|78.7 °F. The downfall is around 2165 millimeter|85.2inches annually. (Source: Bangladesh Meteorological Department).

Duttapara abandoned land

The abandoned land settled on fifty acres of land in Duttapara village beneath Banaripara upazila in Barisal district. It's domestically called bhutterbari or satkina hindubari.

Climate: It's a tropical climate. The summer here have an honest deal of rainfall, whereas the winters have little. The typical annual temperature in 25.9°C|79.6°F. Precipitation here is regarding 2021 millimeter|79.6 inches annually. (Source: Bangladesh Meteorological Department).

Lakutia abandoned land

The abandoned land settled on 49.50 acres of land in Lakutia village beneath Babuganj upazila in Barisal district, was designed by Rup Chandra Roy within the one seventh century. It's located about 8 km north of Barisal city.

Climate: It's a tropical climate. In winter, there's a lot of less downfall than in summer. The typical annual temperature is 25.9°C |78.7°F. The annual downfall is 2184 millimeter | 86.0 inch. (Source: Bangladesh Meteorological Department).

Vegetation sampling

Vegetation analysis and soil sampling were done in October, 2019 to December, 2020.To collect vegetation data (4m×4m) size quadrats were used in all the study sites. A total of nine quadrats were applied at randomly abandoned land of kritipasa (site-1), six quadrats were at Duttapara (site-2) and four quadrats at Lakutia (site-3) at 10m distance from one another. Then amount of plant species and number of individual of various species were recorded in every quadrat. The value of density, relative density, frequency, relative frequency and abundance was calculated. Vegetation data were collected from 9, 6 and 4 different locations from site-1, site-2 and site-3 respectively by placing (4m×4m) quadrats randomly at a distance 10m from each other.

Identification of plant species

As these areas have no legal owners at present, permission had been obtained from the local village authorities to collect plant materials from the study sites. This study was compiled with Bangladesh Biodiversity Act, 2017 (part-2) as a national guideline. Voucher specimens for each plant species were collected and processed according to the standard herbarium techniques [102,103]. Mr. Ashikur Rahman Laskar, Research Scholar, Department of Botany, University of Barisal, identified the collected plant samples consulting a number of Floras[104-112]. The voucher specimens are preserved at Barisal University Herbarium (BUH) for future reference.

Data analysis

Following field data collection, the information was processed and compiled using Microsoft Excel and SPSS. Soil properties were used as an environmental variable for vegetation structure analyses. Of the two main ordination techniques of Redundancy Discriminant Analysis (RDA) and Canonical Correspondence Analysis (CCA)), RDA explained more interspecific variation in soil properties data than the CCA in the present study. Therefore, RDA was used for ordination analysis using log-transformed abundance data each species. The analyzed were performed using the R-Studio software. Species richness rarefaction curve, dominance (D) curve and diversity profile and hierarchical cluster (Dendogram) analysis were conducted using Paleontological Statistics (PAST) software package version 2.17[113]. Phytosociological analysis were conducted following the formulas[114-116].

Analysis of vegetation

After field data were collected, data on quantitative characteristics were compiled and processed for the diversity index. The basal area of the tree species has been calculated using the following equation[117].

Basal area = $\pi D^2/4$; where, D = Diameter at breast height, π = 3.1416

For each species, relative density, relative frequency, relative abundance and significance index (IIV) were calculated. Identified plants have been arranged taxonomically and classified according to their usual form.

Functional Diversity

Functional diversity is defined as the variety of interactions within ecological process and can be quantified by determining the nature and extent to which functional groups are represented in an ecological system[118]. Functional diversity, evenness and richness were measured using different methods.

Generally, species diversity is determined not only by the number of species within a biological community, such as; species richness, but also by the relative abundance of individuals in that community. Species abundance is the number of individuals per species, and relative abundance refers to the uniform distribution of individuals across species within a community. Two communities may be equally rich in species but differ in relative abundance[119].

Four diversity indices, such as, Shannon Wienner Diversity Index (H), Margalef's richness index (BX Simpon's Diversity Index (D). Pielou's Species Evenness Index (E) and Menhinick's richness index (DI) [120-123] and similarity index[124] were analyzed to get a picture of vegetation of abandoned land.

Soil sampling and analysis

Soil samples were collected at 0-15 cm depth from center of every quadrat. Collected soil samples were unbroken in plastic baggage, right away when assortment, soil samples were brought at the Soil Research Development Institute (SRDI) in Barishal division. The collected soil samples was sieved through a 2mm-mesh screen to get rid of plant roots, rocks etc. when sieving, soil samples were analyzed for physico-chemical properties. Soil pH, conductivity, moisture, total nitrogen, potassium phosphorus and organic matter were determined.

The soil PH was determined using digital pH meter. Electrical conductivity was determined by EC meter. Soil moisture content was determined using 10 g fresh soil at 80°C. Total percentage of nitrogen, organic carbon, available phosphorus and potassium were determined by standard protocols[125-128].

Declarations

Author Contributions statement

M.M.H. collected data and performed statistical analysis; M.A.R.L. identified species and analysis; S.K.D provided materials; T.S. contributed substantially to revisions provided resources and supervised; M.T.I. collected data, analysis, processed the raw data and wrote the manuscript.

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Tables

Due to technical limitations the Tables are available as a download in the Supplementary Files.

Figures

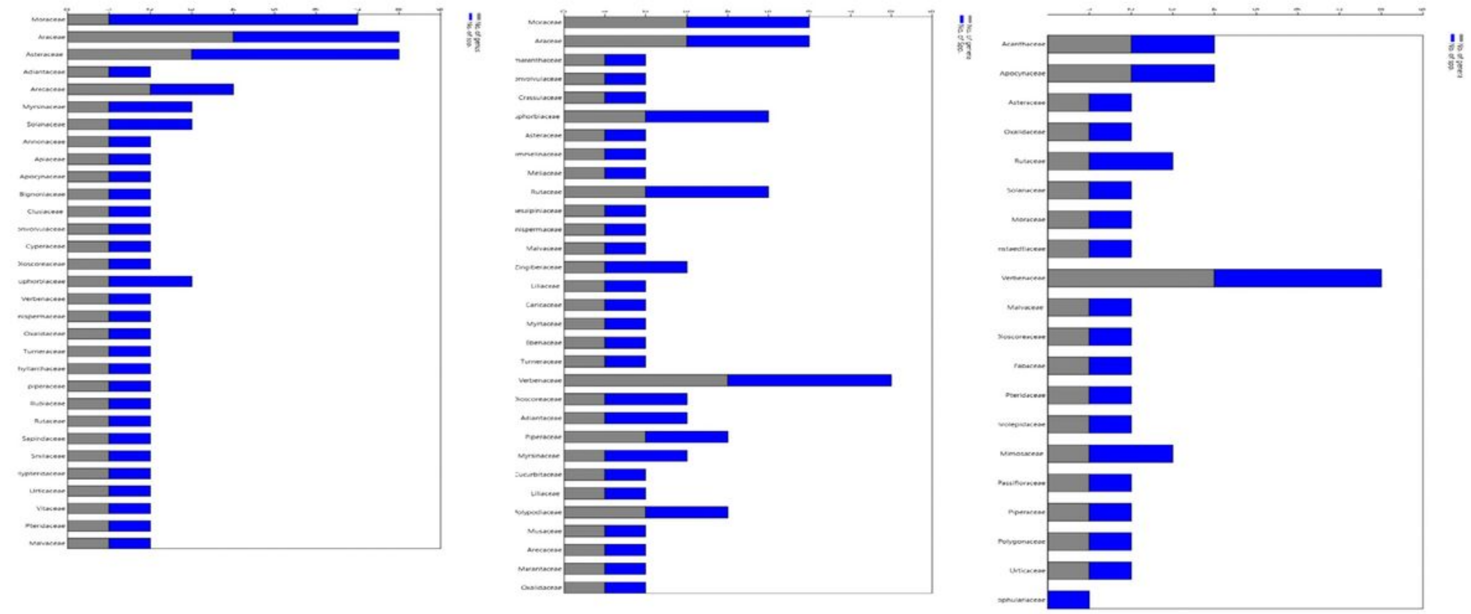

Figure 1

a: Abundance of families found at site-1. b: Abundance of families found at site-2. c: Abundance of families found at site-3.

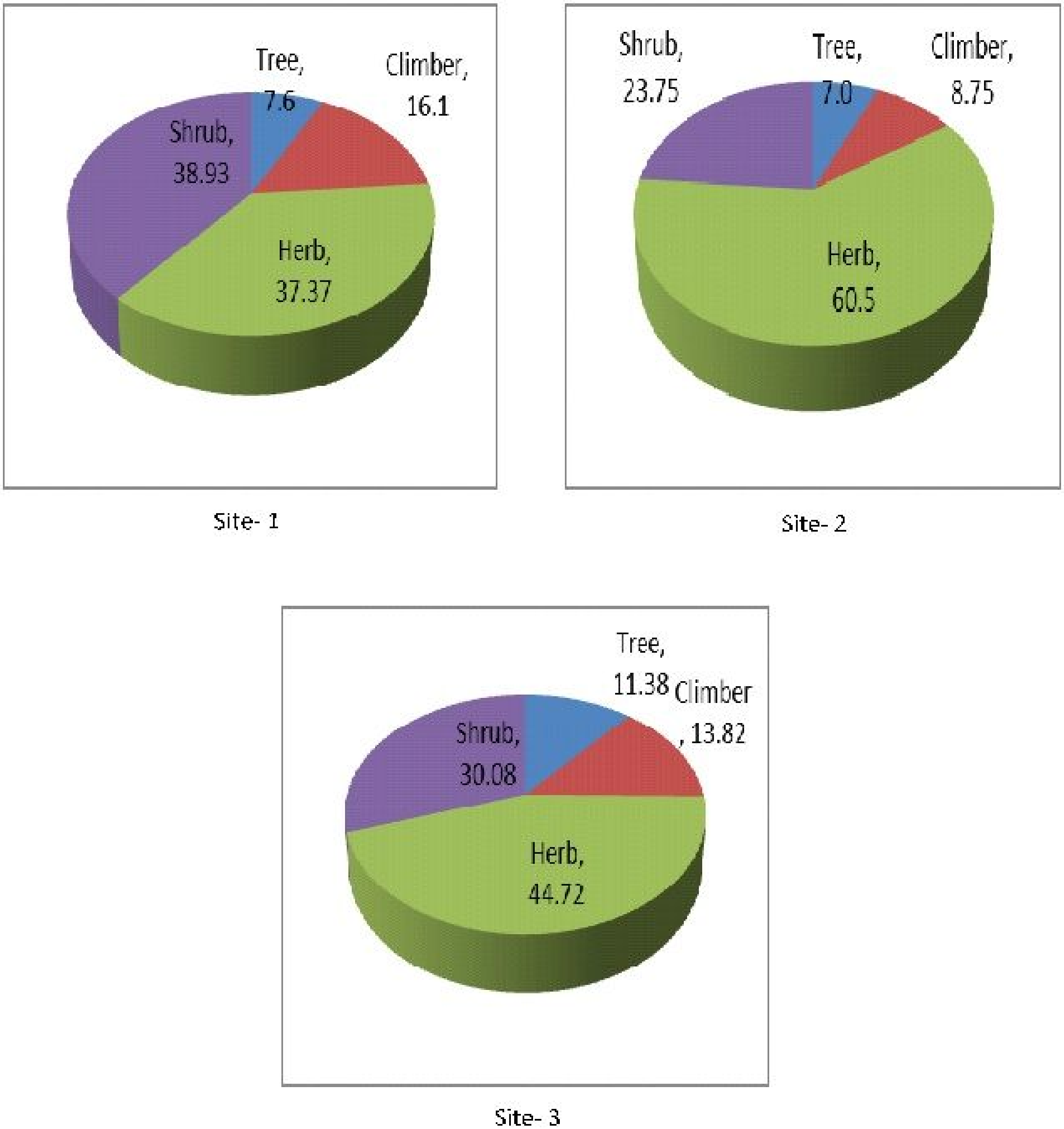

Figure 2

Average herb, shrub, climber and tree percentage.

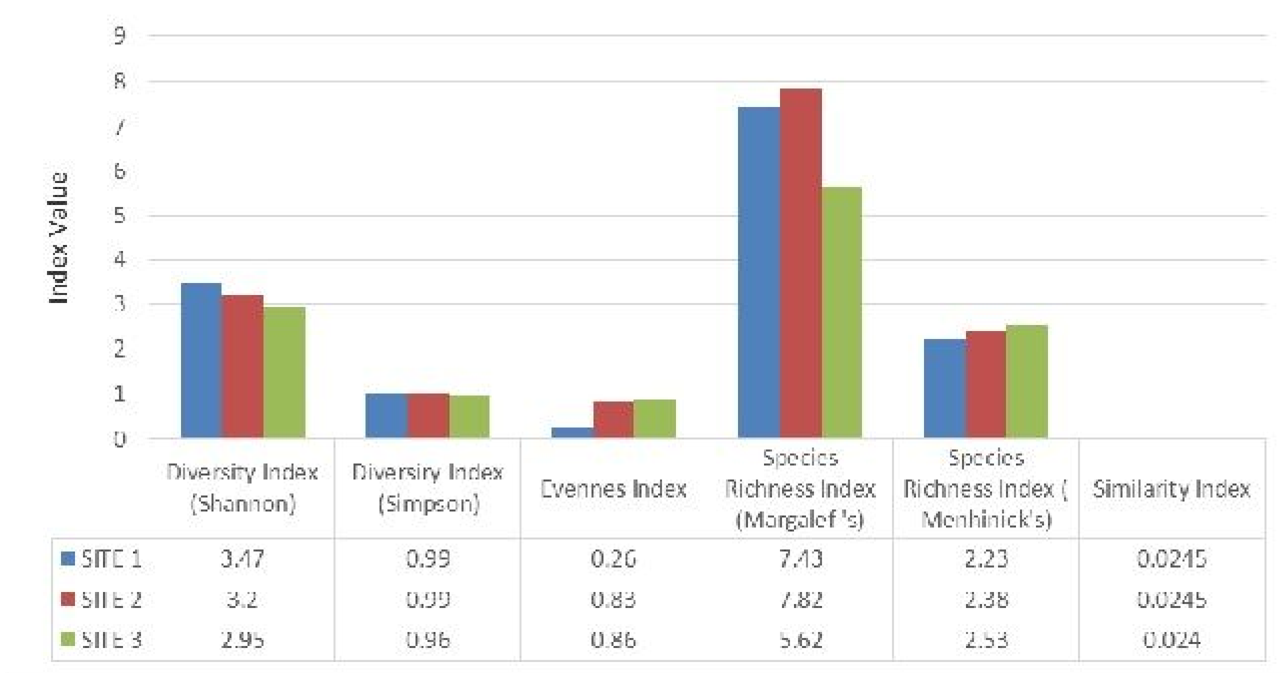

Figure 3

Diversity indices.

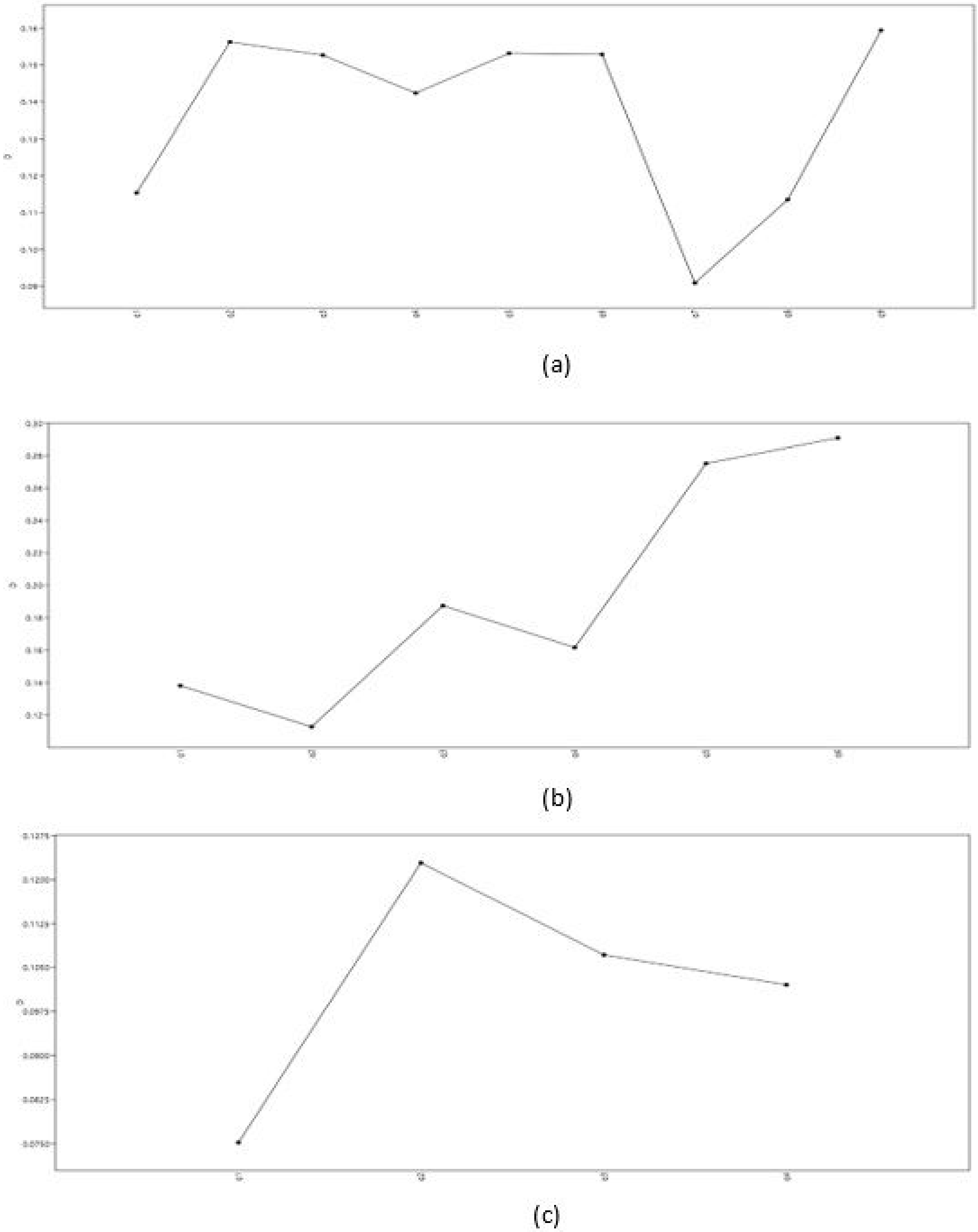

Figure 4

Dominance (D) curve of vegetation species at (a) site-1 (b) site-2 (c) site-3.

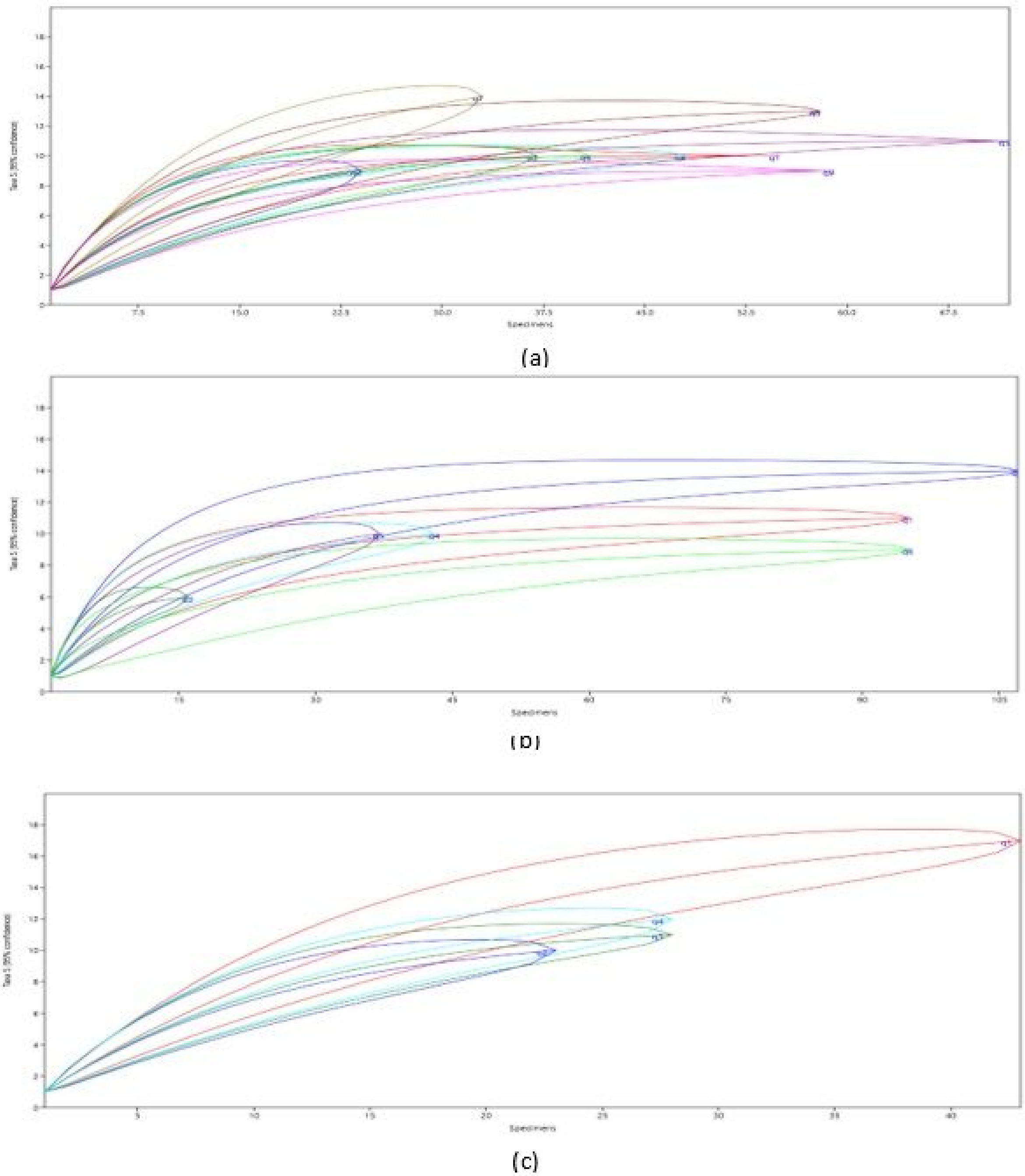

Figure 5

Rarefaction curves of cumulative increase of Plant species richness for (a) site-1 (b) site-2 (c) site-3.

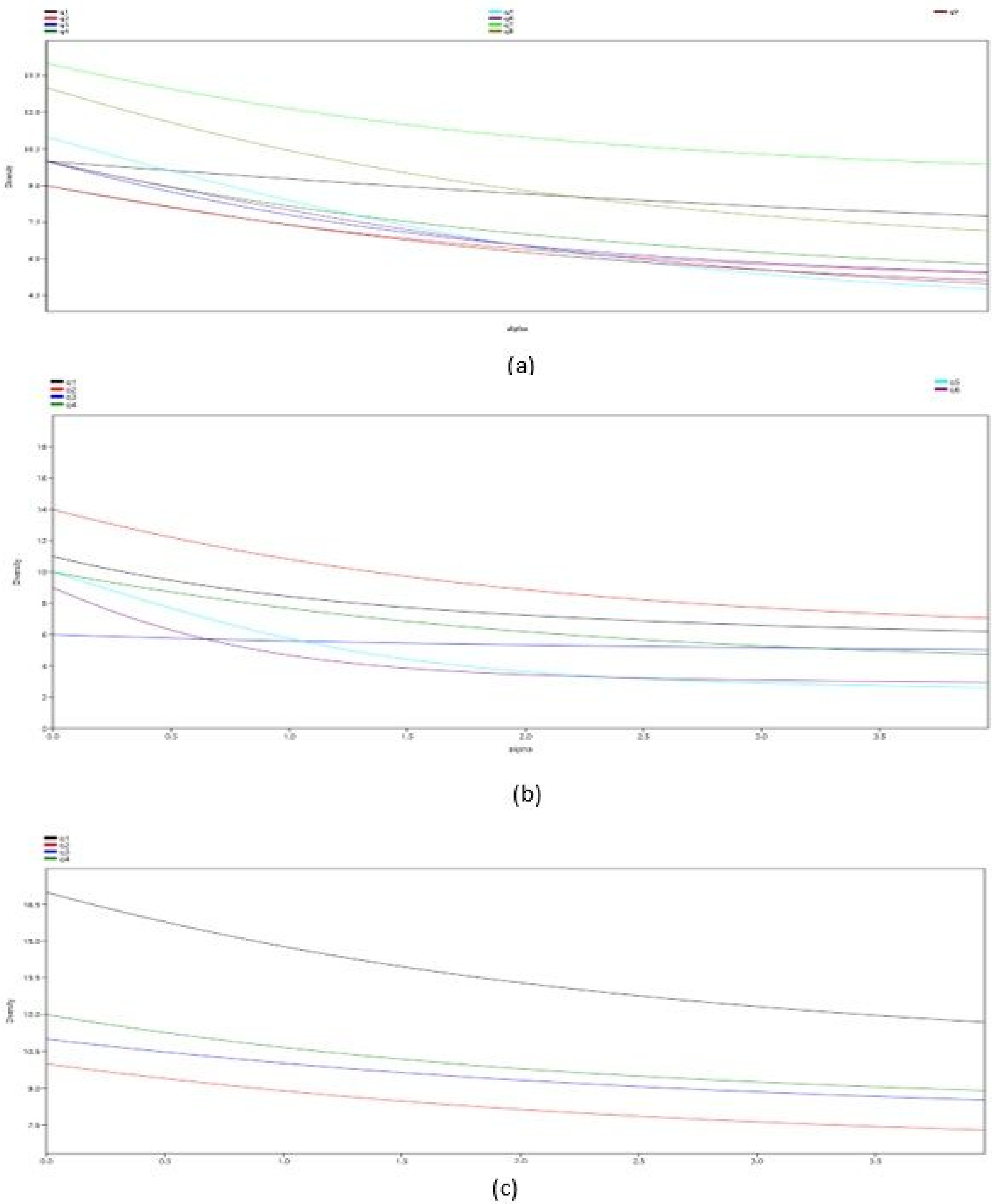

Figure 6

Diversity profile of Plant species at (a) site-1 (b) site-2 (c) site-3.

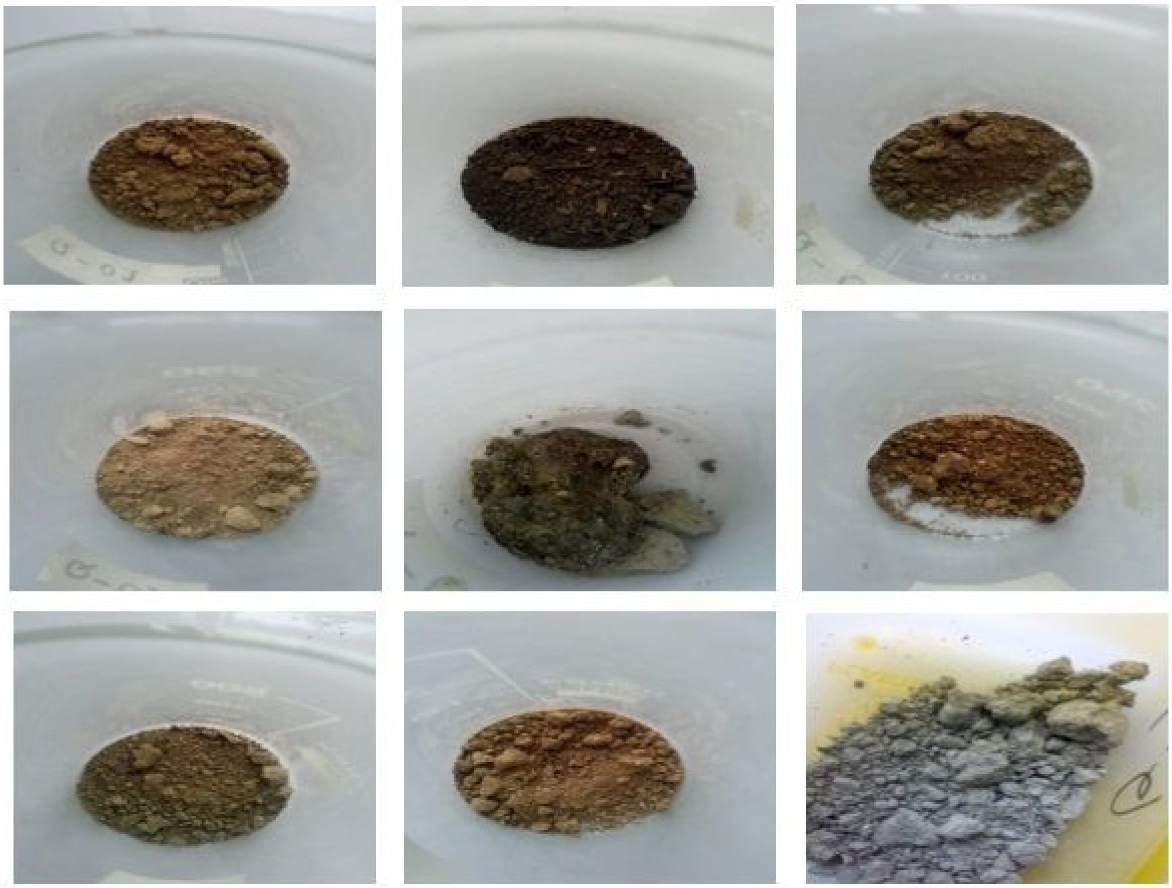

Figure 7

Soil samples collected from study sites.

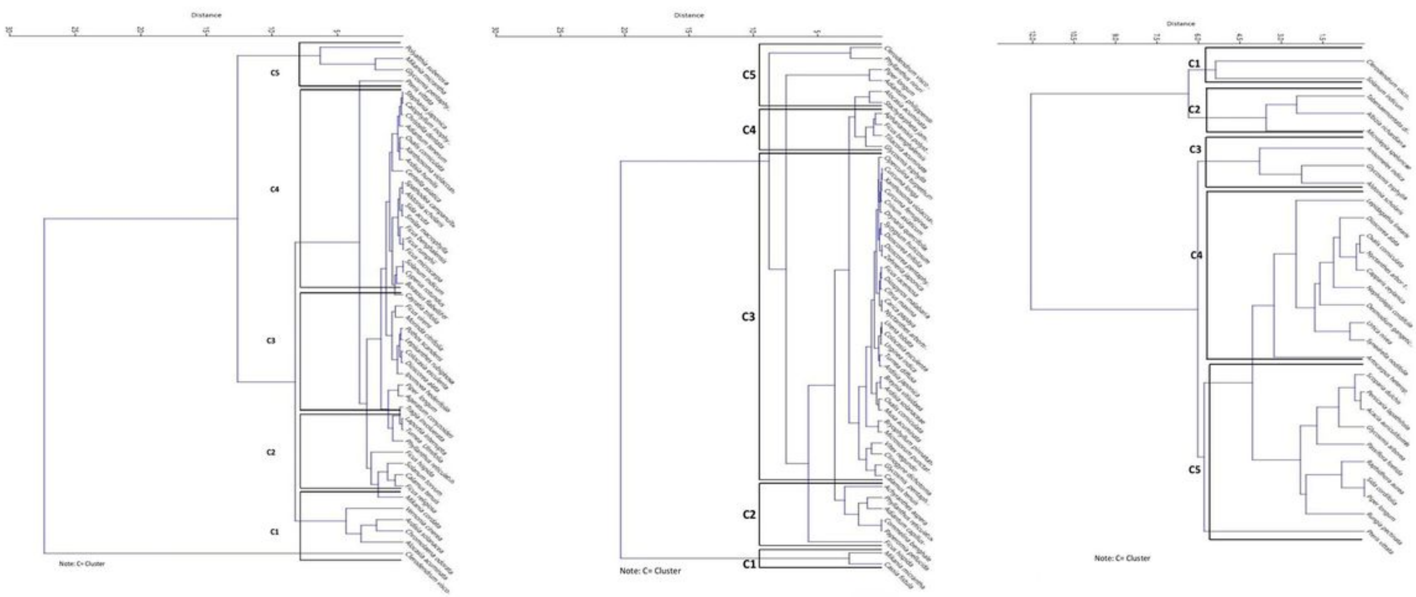

Figure 8

a. Hierarchical cluster of the species at site-1. b. Hierarchical cluster of the species at site-2. c. Hierarchical cluster of the species at site-3.

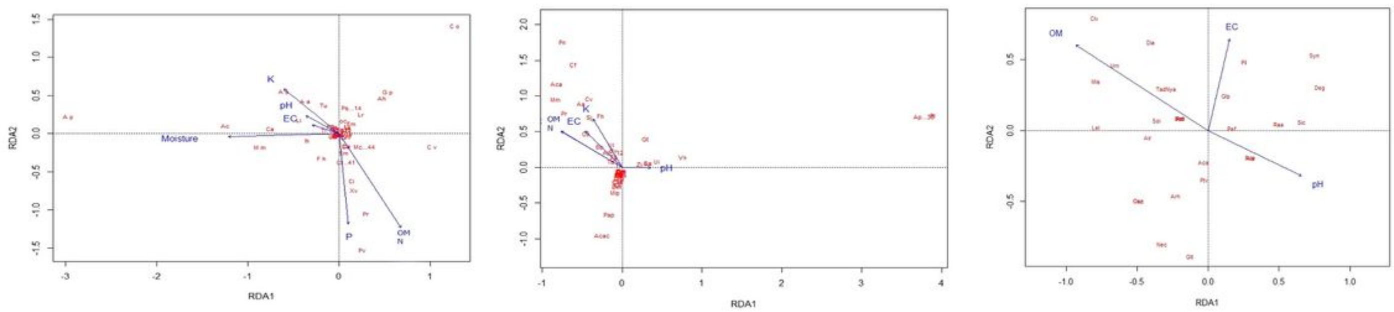

Figure 9

a. Biplot scores of plant species derived from the RDA using species abundance data and soil properties at site-1. b: Biplot scores of plant species derived from the RDA using species abundance data and soil properties at site-2. c: Biplot scores of plant species derived from the RDA using species abundance data and soil properties at site-3.

Supplementary Files

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