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Diversity of medicinal plants and pollution stress indicator plants in kariavattom south campus, university of Kerala, South India

Abstract

The study was conducted during the period January - June 2016 in the Kariyavattom South campus, Thiruvananthapuram, Kerala. The study area is situated at the north east of Thiruvananthapuram city, and 3 km away from the Arabian Sea. The floristic data were assessed using random sampling by the census quadrat method and was followed for the sampling of vegetation for floristic description. About 107 species are present in the selected samples of the study area. Among this, 49 medicinal plants and 17 pollution stress indicator plants were identified. The data of vegetation analysis revealed that the species having high distribution are Microstachys chamaelea (L) Mull, Tragia involucrata L, Wedelia trilobata (L) A. S. Hitchc, Glycosmis pentaphylla (Retz) DC, Chassalia curviflora (Wall. ex Kurz) Thw. var. ophioxyloides, Ixora coccinea L, Memecyclon randerianum SM & MR Almeida and Macaranga peltata (Roxb) Mull -Arg In DC. Pollution stress plant species which shows more distribution are Acacia mangium (Willd) Pedley and Hyptis suaveolens (L) Poit. The plant diversity was predicted using diversity indices. Simpson diversity index of medicinal plants is about 0.6834 and the evenness of this index is about 0.04468. The Simpsons dominant index of pollution stress indicator plants is about 0.8293 and its evenness is 0.0713. The Shannon diversity of medicinal plants and pollution stress plants is about 3.5098 and 1.9919 respectively. The total Mclntoshs diversity index of total medicinal plants is about 6.63 and that of pollution stress indicator plants is about 3.52.

Keywords: medicinal plants, plant diversity, pollution stress indicator plants, species dominance, vegetation analysis

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Introduction

The building blocks of vegetation are the individual plants. A plant community is a part of natural vegetation, it grows, develops and attend into functional unit and is in the state of constant flux with the environment. It has trophic organization and metabolic pattern.[1] The individuals of species, populations, and with the local area of the few square meters to perhaps as much as a square kilometer, groups of plant species populations that are found together are known as plant communities or plant species assemblage.[2] Phytosociology is one of the important aspects for analyzing the structure, composition and phytodiversity for thoroughly understanding the vegetation dynamics. Both structure and diversity of vegetation have strong functional role in controlling ecosystem processes like biomass production, cycling of water and nutrients.[3]

Phyto-sociological study helps to assess the environmental impact assessment, to analyses the level of degradation and conservation management, and also to take appropriate measure for reducing the intensity of degradation. In this study area more problems are related to the acacia tree and it became a weed after many years. The rapid growth of this tree vastly destroyed the associated tree species and plants in the University of Kerala, Kariavattom South campus, Thiruvananthapuram, South India. As a part of the restoration of the diversity of indigenous vegetation in the campus, the present study may help to identify the biodiversity status of present vegetation especially the medicinal plants and air pollution stress indicator plants. The vegetation analysis is very important in order to estimate the vegetation of the area. The study may provide valuable informations about the biodiversity of medicinal plants and pollution stress indicator plants, its distribution pattern, abundance, concentration of dominance and evenness of the species in the study area. The major objective of the study is to assess the diversity of medicinal plants and stress indicator plants in Kariavatton South campus, University of Kerala.

Study area

The study area is situated at the north east of Thiruvananthapuram city, and 3 km away from the Arabian Sea. Teaching/research departments are in the University of Kerala South campus. Formerly in 1980s the land use/land cover of the campus was about 450acres. Subsequently a part of the campus land has been allotted to Techno Park and now remaining area of the south campus is around 367 acres. Geographically Kariyavattom lies between 8°34'6 N latitude and 76°52'51 E longitude at an altitude of 60 m above the sea level. The soil of the study site has been classified as lateritic soil. The Kariyavattom campus is with conserved natural forest vegetation, and is a typical evergreen forest; a pond (Hymavathy pond) of marshy land ecosystem is preserved in the campus. Diversified vegetation is seen in the campus with different types of flora including environmentally important plants, medicinal plants and endemic plants.

Materials and methods

A detailed field survey was conducted and the floristic data was

collected during May- June 2016. Sample location is determined using area coverage maps. In this study used the 10mx10m quadrat and random pattern of sampling by using 10m meter tape Where a grid is difficult to set up for wood land an alternative approach that has been suggested is to called random walk procedure where by a sample point is located taking a random number. Global Positioning System (GPS, Garmin, USA) was used for the fixing exact location. About eight sites were selected they are named as (S1, S2, S3, S4, S5, S6, S7, S8). And information of general site conditions like location, site number, quadrat number, GPS information (longitude and latitude), and record abundance of species based on occurrence and surrounding terrain is noted.[2] Plant species and inflorescence were collected for the identification. Plant samples are identified using different volume of floras.[4] Floristic observation lead to understanding of plant association, by Braun- Blanquet (1928) and found that a more or less stable plant group in equilibrium with its environment, characteristics by definite floristic composition, in which the presence of certain exclusive or nearly exclusive elements, the characteristic species, reveal a particular and self-governing ecology.[5] The important quantitative analysis such as abundance, density, and frequency of tree, herbs and shrubs were determined following the procedures.

$$\text{Abundance } (A) = \frac{\text{Total number of plants of a species in all the quadrats}}{\text{Number of quadrat in which the species occurred}}$$

$$\text{Density } (D) = \frac{\text{Total number of individuals of a species in all the quadrat}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency } (F) = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrat studied}} \times 100$$

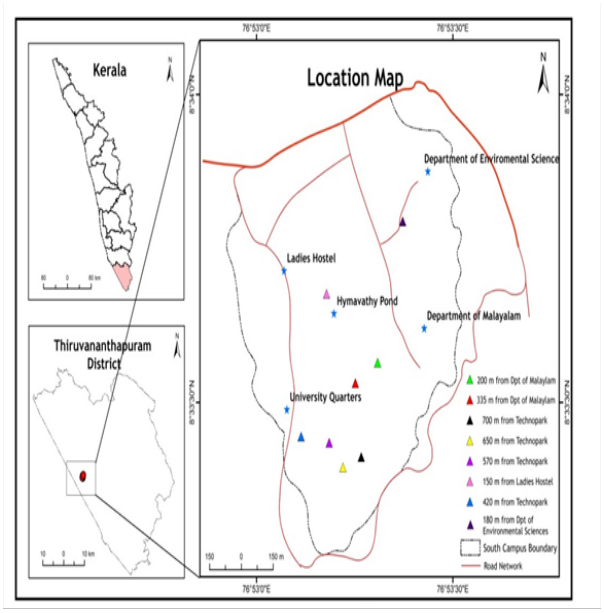

Figure 1 Location Map of Study area showing sampling stations (Kerala University campus).

Diversity indices

A large number of indices of diversity have been devised, each of which seeks to express the diversity of sample or quadrat by a single number. Some indices are also known by more than one name and are presented in different ways (Hill,1973; South wood and Henderson, 2000), of the various, the most frequently used in the simple totaling of species number to give species richness (Mugurran,1998). However, of the indices combining species richness with relative abundance, probably the most widely used are the Simpson index (D) and Shannon index (H'), and also Mclntosh's diversity index (U). It discussed the implication of quadrat size for the collection of data on species richness and diversity. In this present study used the Simpson index (D) and Shannon index (H'), and also Mclntosh's diversity index (U).

Simpson index (D)

Simpson[6] derived an index based on the probability that any two individuals taken at random from an infinitely large community will belong to the same species expressed in the formula:

$$D = \sum pi^2$$

Where pi is the proportion of the number individuals or the abundance of the ith species expressed in the formula:

$$D = \sum \left(\frac{ni[ni-1]}{N[N-1]} \right)$$

Where the n is the number of individuals of the ith species and N is the total number of individuals. The index usually presented as 1-D (the complement) or 1/D (the reciprocal). As the index value increases, diversity decreases. Simpson's index is probably the most widely used diversity index and is the most robust in that it is calculation of the variance is of the species distribution of the sample. The index is most commonly expressed as the reciprocal (1/D). An evenness measure can also obtained by dividing the reciprocal from the index by the number of species in the sample (S).

$$E_{1/D} = \frac{1/D}{S}$$

The result lies between 0 and 1 and is not influenced by species richness

Shannon index (H')

The Shannon-Weiner Index (H') makes the assumption that individuals are randomly sampled from an infinitely large population and also assumes that all the species from a community are included in the sample. Any base of logarithms may be taken, with $\log_2$ and $\log_{10}$ being the most popular choice. The choice must be kept constant

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when comparing diversity between samples. Values of the index usually lies between 1.5 and 3.5, although exceptional cases the value can exceed 4.5.

Diversity index H'=$\sum_{i=1}^{s} pi \ln pi$

Where H'=Shannon-Weiner Index

s = the number of species

Pi= Proportion of the abundance of the i th species

(Pi estimated by ni/N (ni =number of individuals of a species;

N= total number of all the individuals of all the species)

In =log base$_{n}$.

It is also possible to calculate an equitability or evenness index (E) of from;

$$E = \frac{H'}{H'\max} = \frac{\sum_{i=1}^{s} pi \ln pi}{\ln s}$$

E is constrained between 0 and 1.0.

Mclntosh's diversity index (U)

Mclntosh's presented an index (U)

$$U = \sqrt{\sum_{i=1}^{s} ni^2}$$

Where U is the Mclntosh's diversity index, s is the number of species in the quadrat and n is the number of individuals or the abundance of the ith species in the quadrat. The resulting from it depends upon the total abundance of the quadrat sample (N), and it is possible to calculate an index of dominance (D) allowing for N as follows;

$$D = \frac{N - U}{N\sqrt{N}}$$

The lower the dominance (D) value the more uneven the species distribution in the quadrat.

Results and discussion

The list of the species contains 48 medicinal plants. The density of the medicinal plants was found high in the station 1, and the density was found almost same in the station 2 and station 1 (Table 1). And the density is very low in the station 3 and station 4. The density of the medicinal plants is highly varying across the each selected study stations because different communities have different species distribution. The species having high density are *Macaranga peltata* (Roxb) Mull – Arg, In DC, *Memecyclon randerianum* SM&MR AlmeidaI, *Chassalia curviflora* (Wallex Kurz) Thw. var. ophioxyloides, Ixora *coccinea* L, Glycosmis *pentaphylla* (Retz.) DC, *Commelina benghalensis* L, *Acalypha indica* L, and *Indigofera tinctoria* L. the plant which shows less density are *Calophyllum inophyllum* L, *Terminalia catappa* L, *Muntingia calabura* L, *Antidesma bunius* (L) Spreng, *Cassia fistula* L, *Pongamia pinnata* (L) Pierre, and *Azadirachta indica* A, Juss (Table 1).

The phyto-sociological characteristics such frequency distribution of the medicinal plants in the Kariyavattom campus, and the species which have high distribution of frequency are *Indigofera tinctoria* L., *Croton bonplandianus* Baill, *Acalypha indica* L, *Commelina benghalensis* L., *Costuspictus* D. Don ex Lindl, *Synedrelia nodiflora* (L) Gaertn and *Justica gendarussa* Burm. f are above 80% distribution. And species which have less distribution are *Cassia fistula* L, *Muntingia calabura* L, *Antidesma bunius* (L) Spreng and *Calophyllum inophyllum* L. and the medicinal tree species are less than the medicinal shrub and herbs (Table 1). The abundance of the medicinal plants is high in the station 2 and 1, the abundance very low in the station 3. The species which shows high density are the *Microstachys chamaelea* (L) Mull, *Tragia involucrata* L, *Wedelia trilobata* (L) A. S. Hitchc, *Glycosmis pentaphylla* (Retz) DC, *Chassalia curviflora* (Wall. ex Kurz) Thw. var. ophioxyloides, *Ixora coccinea* L., *Memecyclon randerianum* SM&MR Almeida and *Macaranga peltata* (Roxb) Mull -Arg In DC.

The density coverage of the medicinal trees is less, so the tree species coverage is also less in the study area. And it affects the basal area coverage. In the case random small scale plotting, the density and richness of the species are well distinguished[7] recorded that the mean density of trees are lowest so the basal coverage of the trees are also affected. The abundance of the species is directly depending on the species richness.[8] In the present study on the medicinal plant abundance in the selected sites, the high abundance was recorded in station 2. Because large number of shade lowing species are present in this station, so the richness of the herbs and sherbs are also high in the station 2. Station 3 was reported with less abundance of plants because it is a wet land ecosystem. The alternative water logging and marshy land prevents the species richness. And the dominated species are *Indigofera tinctoria* L., *Microstachys chamaelea* (L) Mull, *Wedelia trilobata* (L.) A. S. Hitchc and *Euphorbia hirta* L. The medicinal herb diversity was found more in the study area.

The pollution stress indicator plants in the study area

About 17 species of pollution stress indicator plants were identified in the selected study stations. The identified environmentally important plants are *Anacardium occidentale* L., *Holigarna arnottiana* Hook. f, *Mangifera indica* L, *Polyalthia longifolia* (Sonner.) Thw, *Carica papaya* L, *Tectona grandis*L, *Azadirachta indica* A, Juss, *Artocarpus hirsutua* Lam, *Acacia mangium* (Willd.) Pedley, *Ixora coccinea* L, *Clerodendrum infortunatum* L, *Lantana camera* L, *Terminalia catappa* L, *Pongamia pinnata* (L) Pierre, *Muntingia calabura* L, *Cassia fistula* L and *Hyptis suaveolens* (L) Poit. The total number of tree species are more than the herbs in the selected sampling stations (Table 2). In the present study area, the species s distributed differently in each station. The density of the pollution stress indicator plant species was found more in station 2 and station 3. A also the total density distribution of these two stations are equal, and lowest density is in the station 1and station 4 (Table 2). And the density of pollution stress indicator plant species in two stations are also equal, that is the station 5 and station 6. Station 7 and 8 has more density compared to the station 6. The species which showing high value of density are *Acacia mangium* (Willd) Pedley and *Hyptis suaveolens* (L) Poit. And the species which have less density are *Azadirachta indica* A Juss Thw, *Holigarna arnottiana* Hook. f and *Pongamia pinnata* (L) Pierre ranges from 0.5 to 0.72, and other species have relatively similar density. The abundance of the pollution stress plants are relatively high in the station 1, and it is less in the station 5. Frequency distribution is high in the station 1 and less in the station4. The species which is distributed more in the selected stations include *Lantana camera* L, *Hyptis suaveolens* (L.) Poit, and

Acacia mangium (Willd) Pedley, and less distributed species are *Azadirachta indica* A, Juss and *Pongamia pinnata* (L) Pierre (Table 2). Differential distribution pattern of plants in different stations may be due to the difference in the pollution stress tolerance of plants.

Trees with high dust collecting potential can solve the problems of air particulate pollution to a great extent.[9] Air Pollution Tolerance Index (APTI) of sixteen plant species was high in monsoon season which might be due to the washout of the dust particles from the leaf surface as it increases the photo synthetic activity. Among the selected plants, *Azardirachta indica* A Juss expressed high APTI value. It is a suitable sink to mitigate the air pollution. *Clerodendrum paniculata* L, *Terminalia sp., Pongamia pinnata* L, and *Polyalthia longifonia* Sonn, and showed intermediate tolerant capacity. The plant species *Terminalia catappa* is sensitive to the air pollution in the study area. These sensitive species can be used as the bio indicators of air pollution stress.[10] *Muntingia calabura* L, high level of total chlorophyll observed due to its tolerant nature.[11] Distorted shapes of stomata observed in *Pongamia pinnata* populations exposed to exhaust pollution might have resulted due to lowering of pH in cytoplasm of guard cells and thus a change in turgor relations of the stomata complex and due to physiological injury within the leaf.[12]

Pollution tolerance and dust scavenging capacity of some of the ornamental trees which have aesthetic effect and are tolerant to pollution *(Acacia auriculiforme, Cassia fistula, ferruginous, Tectona grandis and Terminalia arjuna)* have been screened and recommended for planting along the road sides: Emphasis should be given to the native plant species which are comparatively well acclimatized, and stress and pollution tolerant, and also following plant species have been reported as pollution tolerant and recommended for plantation: *Acalypha wilkesiana, Ixora coccinea, Lantana camara, L*.[13] The APTI index of pollution tolerance for plants, *Anacardium occidentale* is 23.20, and for *Mangifera indica* is 23.37, and the result of APTI was high in *Ixora red* (14.32). The APTI of all the plants examined were higher than those of ornamental shrubs; thus, suggesting that plants in general were more tolerant to air pollution than ornamental shrubs. In the study area, different plant species are distributed according to the type of community. The roads in the Kariavattom south campus are with low vehicular intensity, and the study area is free from pollution and is also a conserved ecosystem.

Diversity indices of medicinal plants and pollution stress indicator plants

The Simpson's index, Mclntosh's diversity index (U) and Shannon-Weiner's (1948) index of diversity of medicinal and pollution stress indicator plants were calculated. Simpson's diversity index gives the probability that two individuals selected at random will belong to the same species. The Simpson diversity index of medicinal plants (Table 3) is about 0.6834 and the evenness from this index is about 0.04468. The stations which recorded high value are station8 and station 6, and is lowest in the station 7. The Shannon index of medicinal plants (Table 5) which is about 3.5098 and the evenness is about 0.0716. And less diversity value was station 3 and station 5 is about 3.31, 3.38 respectively. And sampling stations which shows high diversity are station 8 and station 6. And in the case of Mclntosh's diversity index of medicinal plants (Table 7) have the total value is about 6.6340. The Simpson's dominance index of pollution stress indicator plants (Table 4) which is about 0.8293 and its evenness is 0.0713. The dominance index value showing higher in the station 6 have 0.8969 and evenness is about0.065. It is less in the station 3 and 5. And the Shannon index (Table 6) of the present study area has 1.991 and its evenness is about 0.11240. The station have higher diversity value is about 2.4313 in station 6 and it is less in the station 3 and 5 is about 1.3 to 1.4. The Mclntosh's diversity of pollution stress indicator plants is about 3.523 (Table 8).

The dominance of the medicinal plants is high in the station 6 and station 8. And also the pollution indicator plants are also dominant in this station. Simpson's Index is considered a dominance index because it weights towards the abundance of the most common species. And the Simpson's Index value lies between 0 and 1, is not influenced the species richness. The species abundance is directly depends the species richness. A greater number of species and a more even distribution both increase diversity as measured by H'. So the present study area has high diversity of medicinal plants and pollution stress indicator plants. The dominated medicinal plants are *Indigofera tinctoria* L, *Microstachys chamaelea* (L) Mull, *Wedelia trilobata* (L) A. S. Hitchc and *Euphorbia hirta* L. and the dominated environmental important plant species are *Acacia mangium* (Willd) Pedley and *Hyptis suaveolens* (L) Poit. And the species which have less density are *Azadirachta indica* A Juss Thw, *Holigarna arnottiana* Hook. f and *Pongamia pinnata* (L) Pierre.

Table 3 Simpson Index (D) of Medicinal plants

Station No	Simpson index (D)	Evenness (E)
1	0.902038	0.042638
2	0.906122	0.042446
3	0.727273	0.052885
4	0.915123	0.042029
5	0.084877	0.041257
6	0.932245	0.041257
7	0.067755	0.046282
8	0.932245	0.048666
Total	**5.467678**	**0.35746**
Total /8	**0.68346**	**0.044683**

Table 4 Simpson Index (D) of Pollution Stress indicator plants

Station no	Simpson index (D)	Evenness (E)
1	0.8864266	0.0663603
2	0.8864266	0.0663603
3	0.7265625	0.0809614
4	0.8864266	0.0663603
5	0.75	0.0784314
6	0.8969754	0.0655799
7	0.8175583	0.0719503
8	0.7841547	0.0750152
Total	**6.6345307**	**0.571019**
Total /8	**0.8293163**	**0.0713774**

Table 5 Shannon index (H') of Medicinal plants

Station no	Shannon index (H')	Evenness (E)
1	-3.4398169	-0.0702003
2	-3.5030915	-0.0714917
3	-3.3154777	-0.0676628
4	-3.4807175	-0.0710351
5	-3.3867144	-0.0691166
6	-3.7301314	-0.0761251
7	-3.4923268	-0.071272
8	-3.7301314	-0.0761251
Total	**-28.078408**	**-0.5730287**
Total /8	**3.5098009**	**-0.0716286**

Table 6 Shannon Index (H') of Pollution Stress indicator plants

Station no	Shannon index (H')	Evenness (E)
1	-2.338667	0.1375688
2	-2.3459597	0.1379976
3	-1.455333	0.0856076
4	-2.187271	0.1286629
5	-1.3862944	0.0815465
6	-2.4313613	0.1430212
7	-1.9279183	0.0752471
8	-1.8628176	0.1095776
Total	**-15.935622**	**0.8992294**
Total /8	**-1.9919528**	**0.1124037**

Table7 McIntosh's Diversity Index (U) of Pollution Stress Indicator plants

Station no	McIntosh's diversity index (U)
1	3.6912
2	4.8023
3	2.09165
4	1.60078
5	2
6	3.6912
7	5.7662
8	4.5483513
Total	**28.191681**
Total /8	**3.5239602**

Table 8 McIntosh's Diversity of Medicinal plants Index (U)

Station No	McIntosh's diversity index (U)
1	8.87764
2	8.9547
3	5.5565
4	6.07247
5	5.11737
6	6.79613
7	6.83739
8	4.86055
Total	**53.07275**
Total /8	**6.6340938**

Conclusion

The study reveals that about 107 plant species are present in the study area. Among these, 49 medicinal plants and 17 pollution stress indicator plants were identified. The medicinal plants are highly varying across the each selected study stations because different communities have different species distribution. The medicinal plants which show less distribution are *Calophyllum inophyllum* L, *Terminalia catappa* L, *Muntingia calabura* L, *Antidesma bunius* (L) Spreng, *Cassia fistula* L, *Pongamia pinnata* (L) Pierre, and *Azadirachta indica* A, Juss. The more predominant medicinal plant species in the study area include *Microstachys chamaelea* (L) Mull, *Tragia involucrata* L, *Wedelia trilobata* (L) A. S. Hitchc, *Glycosmis pentaphylla* (Retz) DC, *Chassalia curviflora* (Wall. ex Kurz) Thw. var. ophioxyloides, *Ixora coccinea* L, *Memecyclon randerianum* SM&MR Almeida and *Macaranga peltata* (Roxb) Mull -Arg In DC. Pollution stress indicator plants have more distribution and it include *Acacia mangium* (Willd) Pedley and *Hyptis suaveolens* (L) Poit. The less distributed species are *Azadirachta indica* A Juss Thw, *Holigarna arnottiana* Hook. f and Pongamia *pinnata* (L) Pierre. and the more dominant pollution stress indicator plants in the study area are *Acacia mangium* (Willd) Pedley and *Hyptis suaveolens* (L) Poit. These dominant species are homogenously distributed and its density is higher than the other species. So the present study shows that the University of Kerala, Kariyavattom south campus is with more diversified vegetation, and it is vividly proved by the analysis using the Simpson's Index, Shannon index and McIntosh's diversity index. Therefore the present study gives a baseline data of medicinal and pollution stress indicator plants in order to conserve the native flora and fauna of this tropical forest ecosystem.[14–18]

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Conflict of interest

Author declares there is no conflict of interest.

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