



Research Article

Phytosociological Analysis of Moist Temperate Forest in Shah Pur, District Shangla

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Abstract | This study investigates the species composition of moist temperate forests in Shahpur Valley, District Shangla. Fifty 20x20 meter plots were randomly selected across the valley, considering factors like spacing, tree population, size, density, crop variation, altitude, and slope. Tree species were identified and counted in each plot, while soil samples were collected from plots with notable species composition variations. Soil samples were analyzed for parameters like soil organic carbon, pH, and moisture content. Results show *Pinus wallichiana* dominates (53%), followed by *Quercus dilatata* (9%) and *Quercus incana* (8%). Other notable species include *Picea smithiana*, *Robinia pseudoacacia*, *Salix alba*, and *Diospyros*. Shannon's diversity values range from 0 to 1.54, and Simpson's Diversity values from 0 to 0.78. Canonical Correspondence Analysis (CCA) revealed 22 plant species distributed along environmental variables. Key soil factors influencing species distribution include pH (7.38), electrical conductivity (4.67 Sm/cm), moisture content (2.73%), and organic carbon (2.08%). The Shahpur Valley is characterized by coniferous forests, with *Pinus wallichiana* as the most prevalent conifer species. However, primary threats include illegal logging for fuelwood and construction. To address these challenges, alternative fuelwood and construction materials should be provided to local communities. This study contributes to understanding species composition and soil factors influencing forest ecosystems in the region, informing conservation strategies and sustainable forest management practices. Community-led initiatives are necessary to protect the Shahpur Valley's unique biodiversity and promote sustainable forest management. Key findings emphasize the importance of soil properties in shaping forest composition and the need for sustainable practices to conserve this ecosystem.

Received | May 17, 2024; **Accepted** | June 20, 2024; **Published** | June 27, 2024

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Citation | Haq, S., B. Ahmad and B.A. Qazi. 2024. Phytosociological analysis of moist temperate forest in Shah Pur, District Shangla. *Pakistan Journal of Forestry*, 74(1): 40-48.

DOI | <https://dx.doi.org/10.17582/journal.PJF/2024/74.1.40.48>

Keywords | Phytosociology, Species composition, Edaphic factors, Shanon's Index, Simpson index, Biodiversity



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Introduction

Vegetation is a unit which possesses characteristic physiognomic structure which differentiates it from other such units (Hussain and Ilahi, 1991). Environmental gradients, such as topography and

soil variables, shape vegetation structure (Ismail *et al.*, 2019; Khadanga and Jayakumar, 2020). Altitude plays a significant role in shaping vegetation types and diversity, influenced by temperature gradients (Mani, 1978). This, in turn, affects the temperature gradient, which plays a crucial role in shaping vegetation

patterns, diversity, and distribution (Heaney and Proctor, 1989; Tanner *et al.*, 1998; Vazquez and Givnish, 1998). Understanding these dynamics is crucial for managing forest ecosystems.

Braun-Blanquet *et al* (1915) defined the plant community as a group of plants having characteristic species and a stability to the prevailing environment (Podani, 2006). The plant community of a region is a function of many factors such as time, altitude, slope, latitude, aspect, rainfall, soil composition and humidity, all of which play a role in its formation and composition (Kharkwal *et al.*, 2005). The dynamics of plant species development and decline reshape the composition and distribution of species within communities (Watt, 1964). Plant communities undergo seasonal fluctuations and successional changes in response to heat, moisture, and light, influenced by the vegetation itself (Heady, 1958).

Forest ecosystems exhibit variations in structure, composition, and function in response to environmental and anthropogenic factors (Gairola *et al.*, 2008; Timilsina *et al.*, 2007). Habitat variation, time and biotic interactions determine the distribution of individuals of the same and different plant species in a community (Khan *et al.*, 2013). These variations are correlated with geographical location, productivity, evolutionary competition, and human-forest interactions (Eriksson, 1996; Criddle *et al.*, 2003).

Phytosociology, a scientific discipline, focuses on studying plant communities, encompassing their composition, development, and interrelationships among species (Mishra *et al.*, 2012). This field examines vegetation's composition, structure, development, and distribution (Tansley, 1920). Phytosociological analysis serves as a valuable tool for elucidating population trends of individual plant species and comprehending their interrelationships with coexisting species. Phytosociologists employ multivariate statistical techniques to understand vegetation structure and its responses to environmental effects (Ahmad *et al.*, 2019; Dufrêne and Legendre, 1997).

Phytosociology provides a framework to categorize and classify ecological groupings, helping understand plant communities' ecological relationships and the influence of various factors on their organization (Kolasa and Rollo, 1991; Legendre and Fortin,

1989). Oosting (1956) emphasized the importance of phytosociological parameters in understanding spatial patterns and sociological behavior of plants.

Effective forest management requires understanding phytosociological parameters, including diversity indices, species richness, and distribution patterns (Kumar, 2010). Analyzing these parameters provides insights into community relationships and resilience to environmental changes (Magurran, 1988). Indicator species play a crucial role in classifying plant associations and predicting species richness across environments (Dufrêne and Legendre, 1997). These indicators are valuable for monitoring changes in plant communities resulting from environmental or management modifications (Iqbal *et al.*, 2018; Rahman *et al.*, 2020).

This research project has two primary objectives. First, it aims to study the phytosociology and species diversity of the moist temperate forest in the Shahpur Valley, Shangla District. This entails examining the composition, structure, and distribution patterns of plant communities in this distinctive ecosystem. second, this research seeks to identify the soil factors that influence the formation and dispersion of plant communities in the area. By understanding the relationship between soil characteristics and plant distribution, this study will inform evidence-based ecosystem management and conservation strategies in the region.

Materials and Methods

Located in Pakistan's Khyber Pakhtunkhwa province Shangla District, spans an area of approximately 1,586 square kilometers and comprising 28 union councils. Shangla District is located between 33.08° N to 34.31° N latitude and 72.33° E to 73.01° E longitude.

Shangla District is Bounded by Kohistan District to the north, Battagram District to the east, Swat District to the west, and Buner District to the south and also encompasses the Kala Dhaka, or Black Mountain of Hazara, in the east. Shangla District is distinguished by its picturesque valleys nestled among rolling hills and enveloped by forested mountains, hosting coniferous forests with trees like *Picea smithiana*, *Cedrus deodara*, *Pinus wallichiana*, and *Abies pindrow*. Shangla District, s rugged terrain is characterized

by high mountains, steep valleys, and an average elevation ranging from 5,900 to 12,000 feet above sea level (Alpuri Forest Division Working Plan).

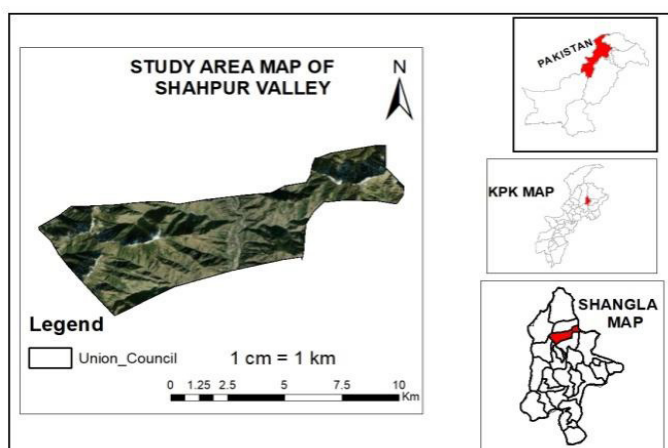


Figure 1: Study area map of Shahpur Valley.

Material

In this research project, various instruments and methodologies were utilized for field data collection. The field data collection instruments employed included Global Positioning System GPS for recording geographical coordinates and elevation data, a clinometer for measuring slope percentages, and a soil auger for collecting soil samples. The collected data subsequently analyzed using software such as including Microsoft Excel and R software.

The field data collection in the Shahpur Area of Shangla District was conducted using systematic and randomized sampling procedures to ensure representativeness and accuracy. For the purpose of this study, the Shahpur Valley was divided into two distinct blocks, Kana East and Kana West, with respective forested areas of 2,060 acres and 2,970 acres. To determine the sampling intensity, the sample area was calculated as 0.1% of the total forest area (5,030 acres). For Kana East, this resulted in 20 sample plots, each measuring 0.1 acre. Kana West, on the other hand, had 30 sample plots of the same size.

The Shahpur Valley comprised a total of 50 sample plots combining Kana East and Kana West Blocks. The standard plot size was approximately 0.1 acres, corresponding to either a circular plot with an 11-meter radius or a 20 x 20-meter square, facilitating efficient data collection.

A stratified random sampling approach was employed, selecting plots from lower elevations to the

tree line, to ensure representation across key factors: Tree population structure, diameter at breast height (DBH), density, species composition, altitude, and slope aspect.

Soil samples were systematically collected from plots showcasing notable species diversity and variation, and were subsequently submitted to laboratory analysis for physical, chemical, and biological characterization. A comprehensive soil analysis was conducted, assessing five key parameters: Moisture content was determined by measuring the difference between fresh weight and oven-dry weight, expressed as a percentage. Ash content was calculated based on the weight loss during ashing, soil organic carbon determined by multiplying the ash content by 0.58.

pH and electrical conductivity (EC) were determined using a soil-to-water suspension, prepared by mixing of air-dried soil with distilled water, shaking for 30 minutes, and measuring with a calibrated pH meter and conductivity probe. These rigorous and systematic methods and analyses were employed to collect high-quality data, providing valuable insights and informing research conclusions.

Results and Discussion

Figure 2 depicts the species composition percentages of sampled plots within the moist temperate forest of Shahpur Valley in Shangla. The sampled tree species encompass both broadleaves and conifers.

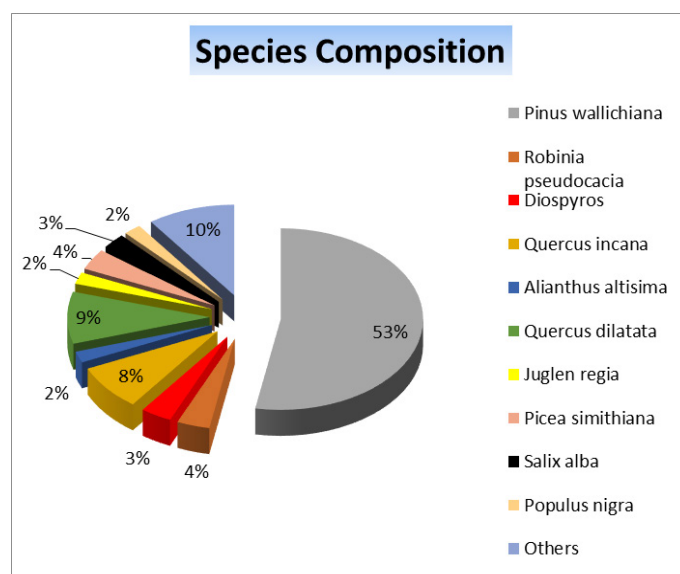


Figure 2: Species composition of moist temperate forest.

Table 1: *Shannon's and Simpson's diversity value of each plots.*

Plot no	Shannon value	Simpson value
1	0.87	0.60
2	0.89	0.52
3	0.89	0.52
4	0.84	0.48
5	0.69	0.50
6	1.00	0.60
7	0.93	0.54
8	1.04	0.63
9	0.64	0.44
10	0.99	0.60
11	0.62	0.43
12	1.30	0.71
13	0.97	0.59
14	1.09	0.66
15	1.49	0.75
16	1.06	0.64
17	1.03	0.62
18	1.14	0.60
19	1.36	0.74
20	1.03	0.62
21	1.26	0.68
22	0.57	0.39
23	0.61	0.42
24	0.69	0.50
25	0.00	0.00
26	0.51	0.33
27	1.09	0.62
28	0.50	0.32
29	1.54	0.78
30	1.36	0.74
31	0.27	0.12
32	0.33	0.18
33	1.35	0.73
34	0.00	0.00
35	1.01	0.54
36	1.35	0.73
37	1.18	0.64
38	0.93	0.54
39	1.00	0.61
40	0.00	0.00
41	0.41	0.20
42	0.85	0.43
43	0.73	0.41
44	0.56	0.38
45	0.43	0.26
46	1.06	0.64
47	0.89	0.52
48	0.38	0.22
49	0.68	0.49
50	1.27	0.65

In ecology, diversity index is an important parameter intended to measure extent of biodiversity within an ecosystem. Two basic statistical tools ecologists use to quantify diversity of species, Shannon's and Simpson's diversity indices, Shannon-Wiener diversity index has been used extensively in environmental studies to estimate the species richness and ecosystem abundance. The index works using very well under comparative situations; where one is comparing two or more environments simultaneously (Omayio and Mzungu, 2019).

Tale 2: *Shannon's diversity value classes.*

Classes values	Count	Range
Zero	3	0-1.54
0 To 1	28	
Above 1	19	

Shannon's diversity index values ranged from 0 to 1.54. Classes with a value of 0 indicated no diversity, which was observed in three classes. Moderate diversity (values between 0 and 1) was found in 28 plots, while 19 plots exhibited high diversity (values above 1).

Table 3: *Simpson's diversity value class.*

Class values	Count	Range
Zero value	3	0-0.78
Above zero	47	

Simpson's diversity values range from 0 to 0.78. A value of zero indicates low diversity, while a value of 0.78 signifies high diversity.

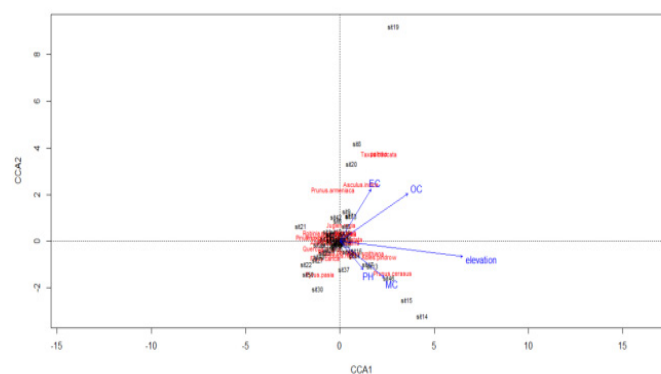


Figure 3: *Canonical correspondence analysis.*

Figure 3 canonical correspondence analysis (CCA) biplot illustrating the relationships between 22 plant species and key environmental variables. In a CCA figure, the longer the arrow line, the more influential or explanatory the environmental factor is. In a CCA biplot, the angle between the arrow lines represents the correlation between environmental factors, where

smaller angles indicate positive correlations, right angles (90°) indicate no correlation, and larger angles indicate negative correlations.

The data indicates that *Pinus wallichiana* is the predominant species in the area, comprising 53% of the total species. The remaining species distribution is *Quercus dilatata* (9%), *Quercus incana* (8%). Both *Picea smithiana* and *Robinia pseudocacia* had a 4% record. *Salix alba* and *Diospyros* make up 3% of the total. Each of the following species makes up 2% of the total species: *Populus nigra*, *Juglans regia*, and *Ailanthus altissima*. The remaining 10% are made up of various others species.

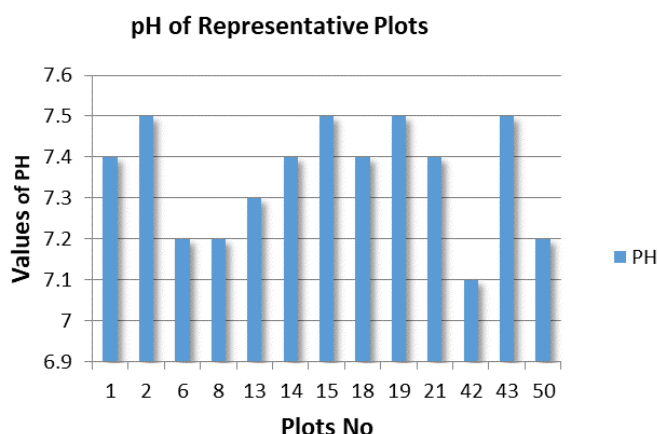


Figure 4: Graphic presentation of Soil pH levels.

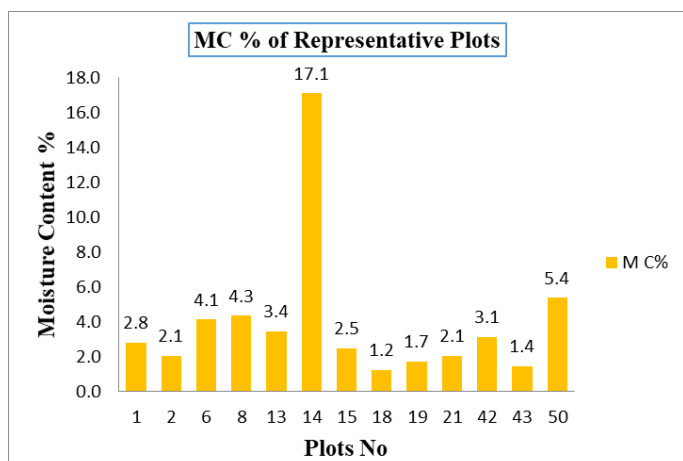


Figure 5: Soil moisture content percentage.

The graph illustrates the soil pH levels for representative plots, ranging from 6.9 to 7.6 on a scale of 0 (most acidic) to 14 (most alkaline), with 7 as neutral. Most plots (majority) exhibit slightly acidic to neutral pH values (7-7.4). Plots 2, 15, 19, and 43 are slightly alkaline, with higher pH values. Plot 42 has a pH of 7.1, nearing neutrality.

Soil moisture content varied significantly across plots, ranging from 1.2% (plots 18 and 43) to 17.1% (plot 14). Most plots had mid-range values (2.1-5.4%). Local conditions, soil type, and recent weather drove these differences.

The Figure 6 displays the electrical conductivity (EC) values of soil samples from various plots, measuring the soil's ability to conduct electrical current and indicating salinity or ion concentration. EC values range from highest: Plot 14 (7.46 dS/m), lowest: plot 6 (3.73 dS/m) and mid-range: 3.2-5.44 dS/m (remaining plots). Higher EC values, like Plot 14's, suggest increased salt concentrations potentially harmful to plant growth. In contrast, Plot 6's lower EC indicates relatively lower salt levels. EC values are typically measured in dS/m or mS/cm.

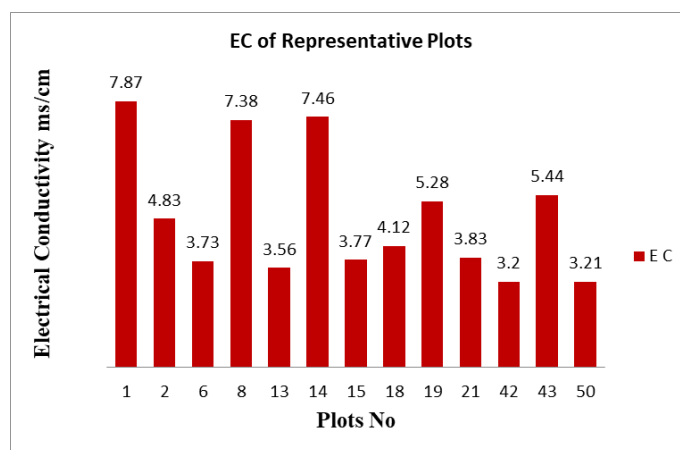


Figure 6: Electric conductivity values of soil samples.

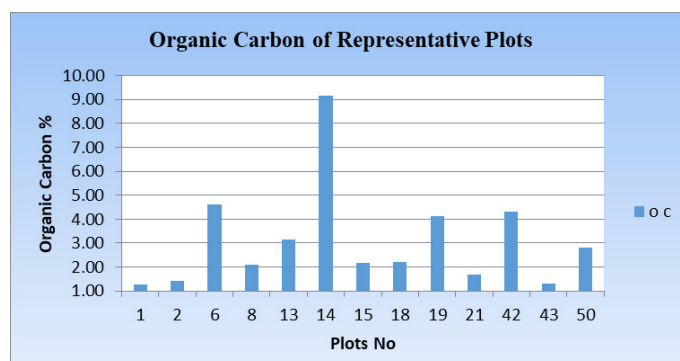


Figure 7: Organic carbon content percentage in soil samples.

Figure 7 presents the organic carbon content (O. carbon) in soil samples from various plots, expressed as a percentage. Organic carbon indicates the presence of decomposed plant and animal materials, reflecting soil organic matter. Highest O. carbon: Plot 14 (9.17%), Lowest O. carbon: Plots 1 (1.25%), 2 (1.43%), and 43 (1.31%) and Mid-range O. carbon:

2.1–4.6% (remaining plots). Plot 14's high organic carbon content suggests fertile soil with enhanced moisture retention and Improved nutrient capacity. In contrast, plots 1, 2, and 43 require organic matter enhancements or targeted soil management practices due to their low organic carbon levels.

Iqbal *et al.* (2014) studied the vegetation of pine forests of Shangla District of Khyber Pakhtunkhwa Province of Pakistan is described. This study selected 30 stands across different locations, where gymnospermic species were found to be widely distributed and dominant in each stand. Sampling was conducted using the point-centered quarter (PCQ) method. *Pinus wallichiana* showed the highest density of 409 trees ha⁻¹, with a basal area of 132.1 m² ha⁻¹, in 26 out of the 30 sampled stands. *Abies pindrow* exhibited moderate abundance, occurring in 7 stands with a density of 384 trees ha⁻¹ and basal area of 145.3 m² ha⁻¹, whereas *Picea smithiana* was scarce, recorded from just 2 sites. The results indicate that young stands had a significantly higher population density compared to mature stands. Our study revealed that the moist temperate forest of Shahpur Valley, Shangla District, exhibits a unique species composition, with *Pinus wallichiana* emerging as the dominant species, accounting for 53% of the total species. *Quercus dilatata* and *Quercus incana* follow, contributing 9% and 8%, respectively. *Picea smithiana* and *Robinia pseudocacia* both make up 4%, while *Salix alba* and *Diospyros* account for 3%. *Populus nigra*, *Juglans regia*, and *Ailanthus altissima* each constitute 2% of the total species composition.

Ismail and Elawad (2015) conducted a comprehensive study to assess plant diversity across 14 selected vegetation sites. They employed the Shannon index, a widely used metric, to quantify species diversity.

Species richness varied across the 14 studied sites, with the highest number of species (19) recorded at Site 2. The highest values for the Shannon diversity index and evenness index were recorded at Site 12. Sites 9 and 10 showed the highest similarity (73.39%), whereas sites 1 and 3 exhibited the lowest similarity (41.83%). Our study's assessment of Shannon's and Simpson's diversity indices revealed that most forest plots exhibit moderate to high diversity levels, indicating a healthy and resilient ecosystem. The Shannon diversity index values ranged from 0 to 1.54, while Simpson's diversity index values ranged from 0 to 0.78.

According to (Khan *et al.*, 2016), the Indus Kohistan valley hosts seven tree species in its pine communities. The study found that the *Pinus wallichiana* was recorded at 23 locations, with the second-highest mean importance value while *Cedrus deodara*, recorded at 28 locations, exhibited the highest mean importance value. According to the study, *Picea smithiana* was recorded at eight locations in the Indus Kohistan valley, achieving the fourth-highest importance value. It was the dominant species in one stand. It ranked as the second dominant species in four stands. *Abies pindrow* was the third most frequent species and correspondingly attained the third-highest mean importance value. *Pinus gerardiana*, *Quercus baloot*, and *Taxus fuana* were the rarest species in the region, characterized by notably low mean importance values. *Cedrus deodara* was dominant in four monospecific stands and was also present in six mixed-species communities.

The *Cedrus-Pinus* community was the most widespread, occurring in 13 stands. The *Abies-Pinus wallichiana* community, found in six locations, was the second-most frequent community in the research area. Notably, it occurred at twice as many locations as the combined total of the *Cedrus-Picea* and *Abies-Picea* communities. The communities of *Pinus wallichiana*, *Picea*, and *Cedrus-Pinus gerardiana* were localized, each occurring in only one location.

Our study revealed that the moist temperate forest of Shahpur Valley, District Shangla, harbors a diverse array of 22 tree species. The species composition is characterized by *Pinus wallichiana* (53%): dominant species, *Quercus dilatata* (9%) and *Quercus incana* (8%): secondary dominants, *Picea smithiana* and *Robinia pseudocacia* (4% each), *Salix alba* and *Diospyros lotus* (3% each), *Populus nigra*, *Juglans regia*, and *Ailanthus altissima* (2% each).

Shaheen *et al.* (2012) surveyed to investigate to assess the diversity of moist temperate forests in the western Himalayas, specifically focusing on the Bagh district Kashmir. As the Simpson's Diversity Index varied from 0.75 to 2.27, while Shannon's Evenness index ranged from 0.21 to 0.71. Our study assessment of Shannon's and Simpson's diversity indices reveals that the majority of the forest plots exhibit moderate to high diversity, indicative of a healthy environment. Shannon's diversity values range from 0 to 1.54 and Simpson's Diversity values range from 0 to 0.78.

Conclusions and Recommendations

The moist temperate forest of Shahpur Valley exhibits a unique species composition, dominated by *Pinus wallichiana* (53%), followed by *Quercus dilatata* (9%) and *Quercus incana* (8%). Other notable species include *Picea smithiana*, *Robinia pseudocacia* (4% each), *Salix alba*, *Diospyros* (3% each), and *Populus nigra*, *Juglans regia*, *Ailanthus altissima* (2% each). Diversity indices show moderate to high diversity (Shannon's: 0-1.54, Simpson's: 0-0.78), indicating a healthy environment. Key soil factors influencing species distribution are pH (7.38), electrical conductivity (4.67 $\mu\text{S}/\text{cm}$), moisture content (2.73%), and organic carbon (2.08%). The study highlights the prevalence of coniferous forests, with *Pinus wallichiana* as the predominant coniferous species. These findings have significant implications for developing effective conservation and management strategies tailored to Shahpur Valley's unique ecological characteristics.

Novelty Statement

A study in Shahpur Valley, District Shangla, revealed its unique conifer-dominated biodiversity. These findings will inform targeted conservation and management strategies to protect the valley's distinct ecological features.

Author's Contribution

Bilal Ahmed Qazi: Conceptualization, Investigation.
 Basheer Ahmad: Wrote the draft and reviewed.
 Samiul Haq: Data curation and editing.

Conflict of interest

The authors have declared no conflict of interest.

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