ORIGINAL RESEARCH PAPER

Botany

INFLUENCE OF PHYSICAL PROPERTIES OF SOIL ON VEGETATION - A COMPARATIVE STUDY

KEY WORDS: Anthropogenic activities, Physical property, Quality of soil, Sacred groves, Vegetation.

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ABSTRACT

The texture and structure of soil system define its physical property and throws light into several parameters like porosity, aeration, moisture content, particle size, water holding capacity and temperature. The above said factors determine the quality of soil which make available water, nutrients and aeration for plants. Therefore, the physical property of a soil has great influence on the natural distribution of diverse plant species including trees, lianas and climbers. With respect to a natural forest ecosystem, the physical properties are generally healthy and sustainable. However, due to various anthropogenic activities in the forest ecosystem and when pressure is high and prolonged, the existing vegetational characteristics may change and become enough to alter the favourable soil and environmental characteristics existing in the ecosystem. This may affect the survival of many endemic plants particularly of tree species in the ecosystem which are essential for providing favourable environment and habitat for many other plant species of natural existence. This change in vegetation and environmental characteristics may cause further reduction in diversity and richness of plant species in an area. The objective of the present study is to analyse the selected physical properties of soil samples collected from selected sacred grove and its nearby disturbed non-sacred grove land. Based on this objective, the study tries to reveal the influence of difference in vegetational stand on soil property and quality.

INTRODUCTION

Physical properties are one of the important parameters of soil which are directly or indirectly correlated to its fertility and productivity. The less diversity and decrease in the vegetation stand can cause reduction in the quantity and quality of organic matter content of the soil. This kind of a situation may lead to decrement in diversity and biomass of microbes in such soil which in turn may affect the decomposition rate of organic matter and may result in poor soil characteristics and quality. The physical properties of soil may have a direct influence on the microbiological process which support the capacity to hold water, water accessibility, buffering in pH, nutrient cycling and capability of soil for exchange of ions. With respect to a natural forest ecosystem, the physical properties are generally healthy and sustainable. However, due to various anthropogenic activities in the forest ecosystem and when pressure is high and prolonged, the existing vegetational characteristics may change and become enough to alter the favourable soil and environmental characteristics existing in the ecosystem. The objective of the present study is to analyse the selected physical properties of soil samples collected from selected sacred grove and its nearby disturbed non-sacred grove land for the comparison. Sacred groves are patches of natural forest vegetation which is conserved by the local people under religious belief. The objectives of present study are to analyze the physical properties (soil moisture content, water holding capacity, bulk density, porosity, pH and electrical conductivity) of soil samples collected from selected sacred grove and nearby disturbed non-sacred grove land. Also compare the physical properties of soil between the sacred grove and disturbed land with respect to two seasons in two consecutive years. Based on this objectives, the study tries to reveal the influence of difference in vegetational stand on soil property and quality.

MATERIALS AND METHODS

1. Soil sample collection

Soil samples are collected in triplicates from core regions of sacred grove, transition region (the buffer region between the grove and disturbed land) and disturbed non-sacred grove regions of the selected study site (Palliyana sacred grove, Vatanapally, Thrissur, Kerala and its nearby disturbed non sacred grove land) at a depth of 30cm from the surface, using the core type soil auger to get comparatively less disturbed Pedon of soil. The soil samples are collected for analysis all the times from previously marked area from each region of study. The soil samples are then carefully transferred to air tight polythene covers and subjected to analysis for physical properties.

2. Analysis of soil physical properties

2.1 Moisture content

Soil moisture is estimated using the gravimetric method. Initial weights of fresh soil samples are recorded and the samples are kept in a hot air oven at 105 °C, until a constant weight is attained. After cooling the sample is taken in a desiccator and the final weight is recorded. Soil moisture of the samples is calculated using the formula:

$$\text{Moisture \%} = \frac{I - F}{I} \times 100$$

Where, I is the Initial weight of the soil (g)
F is the Final weight of the soil (g)

2.2 Water holding capacity, bulk density and porosity

The physical constants like Water holding capacity, bulk density and porosity of the soil samples are determined by Keen Racksowski box method.

Principle:

A known quantity of soil is allowed to fully saturate and equilibrated with water and from the water held in the soil, single value constants namely bulk density, maximum water holding capacity and porosity are determined using Keen Racksowski box.

Procedure:

Fit a suitable filter paper to the perforated base of the box and weigh it in the balance. Pack the box with air dried soil by adding small quantities at a time and tapping the box after each addition to ensure even packing. Continue addition of soil and tapping to pack until the box is nearly full. Level the surface, when the box is completely full. Record the weight of the box with soil. Place the box with soil in a small tray containing water to a depth of half inch and leave it overnight. Remove the box next day and wipe outside with a dry towel and weigh immediately. Using a sharp scalpel remove the expanded wet soil from the box and transfer to a pre-weighed porcelain dish. Weigh the box with residual wet soil. Dry in an oven at 105 °C and weigh to constant weight. In the same way, find out the weight of expanded soil also. From the readings, calculate the physical constants.

Calculations:

Weight of box + filter paper = A g

Weight of box + dry soil = B g

Weight of box + saturated soil = C g

Weight of the box + soil after removing the expanded portion = D g

Weight of the box + soil after drying in oven = E g

Volume of the box $V = \pi r^2 H$

Weight of the soil = E – A g

$$\text{Water holding capacity} = \frac{C-B}{B-A} \times 100$$

$$\text{Bulk density } (g/cm^3) = \frac{\text{Weight of the soil}}{\text{Volume of soil with pore space}} = \frac{B-A}{V}$$

$$\text{Porosity} = \frac{D-E}{V} \times 100$$

2.3. pH

To determine pH at the moisture saturation level, 20 g of soil is dissolved in 100 mL of distilled water (1:5) and stirred with a glass rod for an hour at regular intervals. The pH is determined with a pH meter and expressed directly in pH units associated with the specific dilution of the soil suspension.

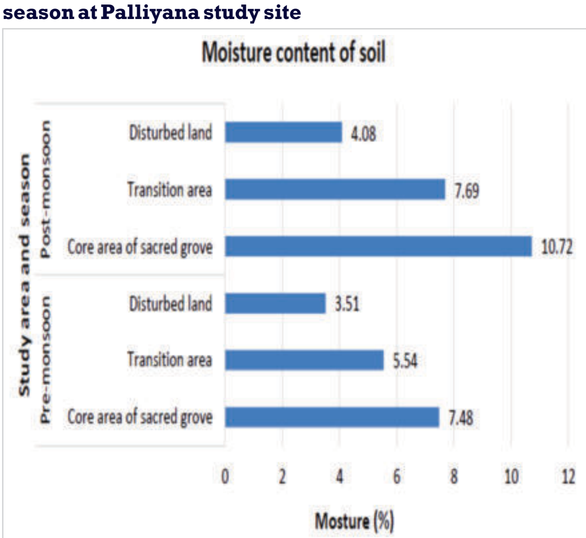
2.4. Electrical conductivity (Electrometric method)

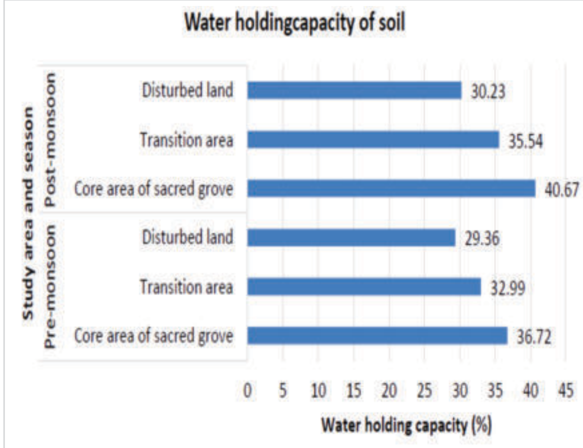
Soil suspension is prepared after shaking a mixture of 20 grams of soil in 100 mL de-ionized water for about an hour. Conductivity of the suspension is measured within an hour by using a conductivity meter. The values are expressed in mho/cm at specific dilution of the soil suspension.

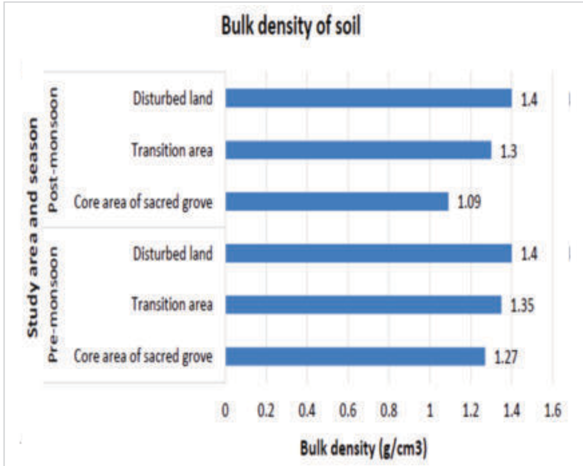
RESULTS AND DISCUSSION

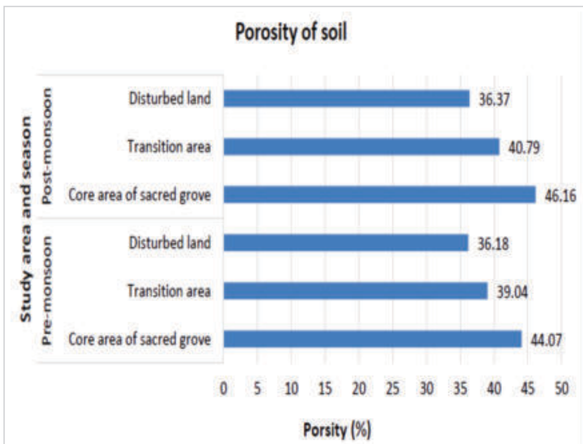
The details of various physical properties of soil samples collected from the core region, the transition region and the disturbed non-sacred region at Palliyana study site during the pre-monsoon as well as the post-monsoon season are shown in the figure 1. The highest soil moisture content is obtained in the core region of sacred grove while the lowest in the disturbed non-sacred grove region, during both the study seasons. The soil moisture level tends to enhance during the post-monsoon period over the pre-monsoon period and are 30.22%, 27.96% and 13.97% higher respectively for core region, transition region and disturbed land.

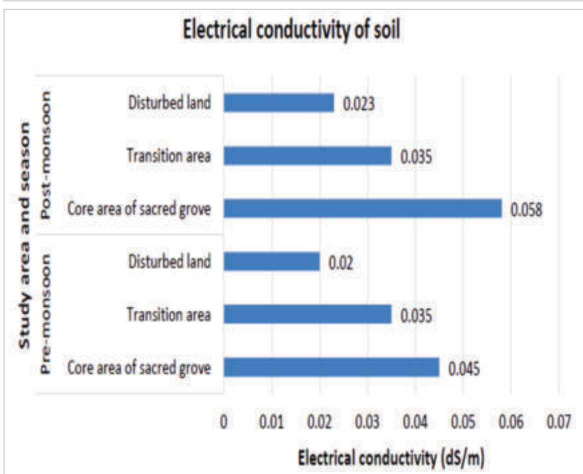
Figure 1: The status of various physical properties of soil samples collected from different regions in different season at Palliyana study site

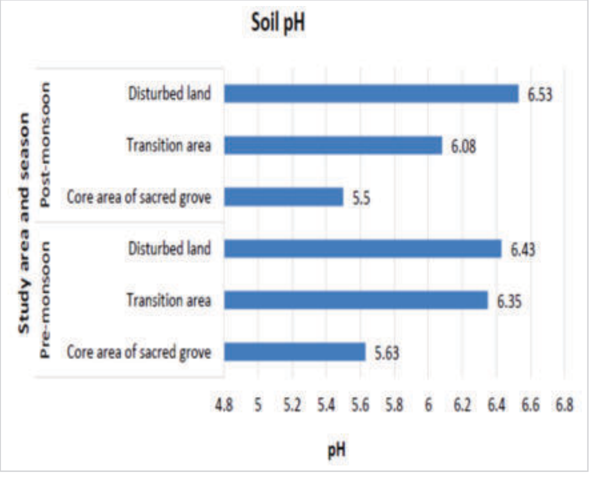












The soil porosity data indicates difference between various soil samples during the pre-monsoon and the post-monsoon periods. The comparison of data obtained in two different seasons indicate the soil porosity values in all the study regions of Palliyana site tend to increase during the post-monsoon period over the pre-monsoon values and the increase is 4.53%, 4.28% and 0.51% respectively for core, transition and disturbed region.

The bulk density values show a decreasing trend from the soil of disturbed non-sacred grove land to region of transition and then the core region of sacred grove, irrespective of the sampling periods. In the pre-monsoon period, an average bulk density of 1.27 g/cm^3 is recorded at core region while an average of 1.35 g/cm^3 and 1.40 g/cm^3 are recorded at region of transition and disturbed land respectively. During the post-monsoon period, the average bulk density value of 1.09 g/cm^3, 1.30 g/cm^3 and 1.40 g/cm^3 are recorded respectively for core, transition and disturbed region. The data showed an enhancement in the soil water holding capacity value for all the study regions during the post-monsoon period over the pre-monsoon period. An enhancement of 9.71%, 7.18% and 2.88% is recorded respectively for core, transition and disturbed regions. The lowest pH value of 5.63 and 5.5 is recorded in the core region of sacred grove during the pre-monsoon and post-monsoon period respectively while highest values of 6.43 and 6.53 recorded respectively in the disturbed land. The values indicate an increasing trend in the soil pH from core to transition and then to disturbed land. Soil electrical conductivity varies with soil samples collected from core, transition and disturbed land and the values are found to range from 0.02dS/m to 0.045dS/m during the pre-monsoon and from 0.023dS/m to 0.058dS/m during the post-monsoon periods. The results show a decreasing trend in the EC value with the highest value being recorded in the soil of core region and then decrease in the direction of transition region and the lowest value recorded in the disturbed non-sacred grove region. The higher soil moisture content and water holding capacity in the grove area could be the result of reduced surface evaporation due to higher floristic composition and distribution. However, the lower moisture content and water holding capacity of soil in the disturbed and transition regions compared to the grove regions in the present study could be the result of faster evaporation loss of water from the floor area. The poor floristic composition-oriented reduction in litter falls deposition and their decomposition and direct falling of sunlight in the ground area due to poor tree canopy cover are the major factors contributing towards higher loss of surface water in the disturbed land. The bulk density is one of the key factors which determine the soil environment for microbial activity and nutrient availability. The present study clearly reveals that there are differences in bulk density between soil of various regions in the study site and the values are found increasing in the direction of core region of sacred grove → the transition region → disturbed non-sacred grove region. The influence of seasonal variation in the bulk density values of soil reveal that with the exception of soil in the disturbed non-sacred grove region, the values in all the regions tend to decrease during the post-monsoon period over the pre-monsoon values.

The statistical analysis revealed the differences are maximum and significant between the bulk density values of soil in the core region of grove and disturbed non-sacred region in the study site during both the season. However, the lower bulk density values in the soil of sacred grove regions can be attributed to the vigorous growth of the tree root systems in the area combined with the influence of rich humus content in the soil as a result of frequent addition of leaf litter and their decomposition by microorganisms. The present study observations and interpretations are in similar lines with the reports of Nambiar and Sands (1992) and Enrique et al. (2015) on the bulk density and porosity of soil. Porosity is one of the important soil physical factors to be considered with respect to quality of soil as it decides the space for storage, the movement of groundwater and infiltration property of the soil. The porosity values are found greater in the soil of core region of sacred grove which is immediately followed by transition region and the lowest porosity is recorded in the disturbed non-sacred region. The study further revealed the porosity values of soil generally tend to improve during the post-monsoon period over the pre-monsoon values. Statistical analysis revealed that the difference in soil porosity values between the core region of grove and non-sacred grove regions are significant. The better porosity values in the soil of sacred grove might be the result of fine-textured soil in the area. The fine components formed by the microbial decomposition of thick deposition of leaf litter particularly of trees in the grove area are usually less dense than the mineral components which may favour the building of fine textured soil by lowering of bulk density and improving the air space between and within the soil aggregates (Kêsik et al., 2010; Portella et al., 2012). Soil electrical conductivity is the ability of soil water to carry the electrical current and this can provide a good indication of the amount of nutrients available for the plants to absorb. The present study shows the soil in the sacred grove region recorded comparatively higher EC value over other region in the study site during the pre-monsoon as well as post-monsoon seasons. The higher electric conductivity value in the core region of grove may be attributed to the higher release of soluble inorganic ions from the rich soil organic matter, favoured by increased soil porosity and higher moisture content (Granged, 2011).

The study generally observes a negative correlation between electric conductivity value and bulk density in the analysed soil samples while there is a positive correlation between electric conductivity value, porosity, moisture content and inorganic matter content of analysed soil samples in the study site. The soil pH values are found within the acidic range in the study site. Comparatively lower pH values are recorded in the soil of core region during both the seasons and the values are found gradually increasing in the direction of transition region and then disturbed non-sacred grove region. Comparing the pH values obtained during different seasons, soil samples collected during the post monsoon season recorded higher values than during the pre-monsoon. Higher production of organic acids and CO_2 due to higher decomposition rate of rich dead organic matter in the soil of sacred grove by microbial activity and their higher accumulation due to comparatively low rate of leaching could be the result of lower pH values (Arunachalam & Arunachalam, 1999). The study observed that the soil in the transition region in the study site is found holding comparatively better soil physical properties compared to disturbed non-sacred grove regions. This can be attributed to the influence of dead plant residues and the decomposed organic matter contents that are distributed and leaching from the grove regions to the region of transition.

Table 1: Comparison of soil moisture content in various regions of the selected study site during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of soil moisture content (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Palliyana site	7.48 ±1.12	5.54 ±0.93	3.51 ±0.59	10.72 ±1.66	7.69 ±2.04	4.08 ±0.70

Study site	The 't' value and significant level in the average soil moisture content			
	Pre-monsoon	Post-monsoon	Pre-monsoon X Post-monsoon	
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land
Palliyana site	6.270	7.386	-3.239	-1.245
	P<0.001	P<0.001	P<0.05	NS*

Table 2: Comparison of water holding capacity of soil in various regions of the selected study site during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of water holdingcapacity of soil (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Palliyana site	36.72±1.14	32.99 ±0.82	29.36 ±0.70	40.67 ±0.56	35.54±0.52	30.23±1.10

Study site	The 't' value and significant level in the water holding capacity			
	Pre-monsoon	Post-monsoon	Pre-monsoon X Post-monsoon	
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land
Palliyana site	10.990	16.947	-6.208	-1.343
	P<0.001	P<0.001	P<0.001	NS*

Table 3: Comparison of bulk density of soil in various regions of the selected study site during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of bulk density of soil (g/cm^3)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Palliyana site	1.27±0.09	1.35±0.05	1.40±0.08	1.09±0.05	1.30±0.03	1.40±0.03

Study site	The 't' value and significant level in the average bulk density			
	Pre-monsoon	Post-monsoon	Pre-monsoon X Post-monsoon	
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land
Palliyana site	-2.227	-10.333	3.486	.059
	P<0.05	P<0.001	P<0.05	NS*

Table 4: Comparison of soil porosity in various regions of the selected study site during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of soil porosity (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Palliyana site	44.07±0.93	39.04 ±1.57	36.18 ±0.99	46.16 ±2.0	40.79 ±2.0	36.37

Study site	The 't' value and significant level of average soil porosity			
	Pre-monsoon	Post-monsoon	Pre-monsoon X Post-monsoon	
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land
Palliyana site	11.629	8.683	-1.900	-0.256
	P<0.001	P<0.001	NS*	NS*

Table 5: Comparison of soil electrical conductivity in various regions of the selected study site during the pre-monsoon season and post-monsoon periods

<table>
<tr><th rowspan="3">Study site</th><th colspan="6">Mean value and SD of soil electrical conductivity (dS/m)</th></tr>
<tr><th colspan="3">Pre-monsoon</th><th colspan="3">Post-monsoon</th></tr>
<tr><td>Core zone of grove</td><td>Transition zone</td><td>Disturbed non-sacred grove land</td><td>Core zone of grove</td><td>Transition zone</td><td>Disturbed non-sacred grove land</td></tr>
<tr><th rowspan="7">Palliyana site</th><td>0.045±0.013</td><td>0.035 ±0.021</td><td>0.020±0.008</td><td>0.058 ±0.017</td><td>0.035±0.013</td><td>0.023±0.013</td></tr>
<tr><th colspan="6">The 't' value and significant level in the average soil electrical conductivity</th></tr>
<tr><th colspan="2">Pre-monsoon</th><th colspan="2">Post-monsoon</th><th colspan="2">Pre-monsoon X Post-monsoon</th></tr>
<tr><td colspan="2">Core zone of grove
X
Disturbed non-sacred grove land</td><td colspan="2">Core zone of grove
X
Disturbed non-sacred grove land</td><td>Core zone of grove
X
Core zone of grove</td><td>Disturbed non-sacred grove land
X
Disturbed non-sacred grove land</td></tr>
<tr><td colspan="2">3.273</td><td colspan="2">3.300</td><td>-1.168</td><td>-0.333</td></tr>
<tr><td colspan="2">P<0.05</td><td colspan="2">P<0.05</td><td>NS*</td><td>NS*</td></tr>
</table>

Table 6: Comparison of soil pH in various regions of the selected study site during the pre-monsoon and post-monsoon periods

<table>
<tr><th rowspan="3">Study site</th><th colspan="6">Mean value and SD of soil pH</th></tr>
<tr><th colspan="3">Pre-monsoon</th><th colspan="3">Post-monsoon</th></tr>
<tr><td>Core zone of grove</td><td>Transition zone</td><td>Disturbed non-sacred grove land</td><td>Core zone of grove</td><td>Transition zone</td><td>Disturbed non-sacred grove land</td></tr>
<tr><th rowspan="7">Palliyana site</th><td>5.63±0.1</td><td>6.35±0.06</td><td>6.43±0.1</td><td>5.50±0.14</td><td>6.08±0.013</td><td>6.53±0.01</td></tr>
<tr><th colspan="6">The 't' value and significant level in the average soil pH</th></tr>
<tr><th colspan="2">Pre-monsoon</th><th colspan="2">Post-monsoon</th><th colspan="2">Pre-monsoon X Post-monsoon</th></tr>
<tr><td colspan="2">Core zone of grove
X
Disturbed non-sacred grove land</td><td colspan="2">Core zone of grove
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Disturbed non-sacred grove land</td><td>Core zone of grove
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Core zone of grove</td><td>Disturbed non-sacred grove land
X
Disturbed non-sacred grove land</td></tr>
<tr><td colspan="2">-11.817</td><td colspan="2">-12.004</td><td>1.464</td><td>-1.477</td></tr>
<tr><td colspan="2">P<0.001</td><td colspan="2">P<0.001</td><td>NS*</td><td>NS*</td></tr>
</table>

NS* - Not significant

CONCLUSION

The studies on the physical properties of soil in the sacred grove region, transition region and highly disturbed non-sacred grove region in the study site clearly revealed significant role of sacred grove or undisturbed forest vegetation in the maintenance of quality and productivity of the soil. Higher floristic composition and diversity, higher microbial population and high rate of litter decomposition in the grove area compared to other areas of study could be the reason for better physical properties. The good physical parameters of the soil in the grove such as high soil porosity, moisture content and water holding capacity are clear indications of influence by rich vegetation stand and high organic matter content in the area. So, the enriched soil of sacred grove helps to enhance the soil fertility of nearby places by leaching process and it is clearly observed in the transition regions over the disturbed region. The lower or undesirable status of physical parameters recorded in the soil of disturbed non-sacred grove region is a clear indication of human interference and disturbances. The present study finds that, the soil in the grove and immediate transition region are found with improved quality during the post-monsoon period over the pre-monsoon status and the soil physical properties have been considered to exert great influence on the distribution, growth and development of plant species. Therefore, appropriate conservation strategies are to be taken to ensure the long-term sustainability of existing groves which are essential for the maintenance of ecological environment in the future.

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