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Evaluation of soil microbes from Tropical Thorn Forest of foot hills of Niligris, Jackanari Reserve Forest, Tamil Nadu, India in relation to soil physical and chemical properties

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Abstract

An evaluation of microbial population was undertaken with the collection of fifteen soils samples from tropical thorn forest soils at foot hills of the Niligris, Jackanari reserve forest, Tamil Nadu, India. The organic carbon of these soils was found to be fairly good and ranged from 0.03 to 0.63 %. The population of bacteria, actinomycetes and fungi were enumerated using serial dilution and plating technique. The correlation between the organic carbon and microbial population of the soils exhibit a significant positive correlation, whereas Bulk density and EC of the soil showed negative correlation for microbial population**.** The results of this study indicate that increase in organic carbon has increased the population of Bacteria, Actinomycetes, and Fungi.

Key words: Microbial population, Organic carbon, EC, Bulk density, The Nilgiris.

Introduction

Forests and forest soils play a broad, complex and interactive role within the environment. Soils have provided the foundation for trees and entire forests over millions of years. Soil is an important component of forest and woodland ecosystems as it helps regulate important ecosystem processes, such as nutrient uptake, decomposition, and water availability. Soil microorganisms play an important role in soil processes that determine plant productivity. Soil fungi make a very important part of the ecosystem along with other microbes in turnover of the biomass. Soil microorganisms participate in a wide variety of metabolic and physiological activities that constantly change the microhabitat. Rhizosphere is the zone of plant root influencing soil volume where there is a high concentration of carbon with zone of intense microbial metabolic activity (James & Hyde ,1998). The soil microbes decompose the plant and animal residues and convert them into soil organic matter, which influences the soil physical, chemical and biological properties. (Olson *et al*. 2000).

Considering the scenario of Tamil Nadu, Nilgiri biosphere reserve is the most important biodiversity hotspot in India and it caters to the environmental requirement of human beings including carbon sequestration. It contains a wide variety of flora and soil highly rich in organic matter and suitable for the growth of microorganisms. Reports on the microbial population is scare. Hence this study has been taken up to analyze the diversity of soil microbes in Tropical thorn forest of Niligri biosphere reserve in Tamil Nadu.

Materials and methods

A) Study area

The Nilgiri Biosphere Reserve encompasses 5,520 km² in the states of Karnataka (1527.4 km²), Kerala (1455.4 km²), and Tamil Nadu (2537.6 km²). The Biosphere lies between 11° 36' to 12° 00' N Latitude and 76° 00' to 77° 15' E Longitude. The Nilgiri Biosphere Reserve includes all the important forest types that are to be found in South India as well as some that are just peculiar to the belt such as Tropical thorn forest, Tropical dry deciduous forests, Tropical moist deciduous forests, Tropical semi evergreen forests, Sub tropical broad leaved forests, Tropical wet evergreen forests, Southern montane wet temperate forests, Southern montane wet grasslands and Subtropical hill savannas. Hence it is a peculiar ecosystem.

The foot hills of Nilgiri biosphere reserve consists of majority of the forest types mostly they are tropical torn forest, tropical dry deciduous forest and tropical moist deciduous forest (Champion *et al*. 1968)

This study is mainly concentrated to the tropical thorn foot hills of Nilgiri biosphere reserve of Tamil Nadu.

B) Collection of soil samples

Fifteen soil samples were collected at the depth of 10-15 cm in sterile plastic bags from different locations of Tropical thorn forest in the foot hills of Nilgiri biosphere of Tamil Nadu, India. All samples were labeled and refrigerated for further investigation. The period of the study was June 2015 to August 2015.

Table 1. Soil sample collection in different locations

Soil Sample	Latitude	Longitude	Mean sea level (M)
1	N 11^0 20' 09.9"	E 076^0 56' 17.4"	343
2	N 11^0 20' 11.6"	E 076^0 56' 24.9 "	340
3	N 11^0 20' 27.4"	E 076^0 56' 53.4 "	330
4	N 11^0 20' 44.4"	E 076^0 57' 02.1 "	337
5	N 11^0 20' 47.2"	E 076^0 56' 55.6 "	346
6	N 11^0 20' 16.4"	E 076^0 56' 09.3 "	363
7	N 11^0 20' 16.1"	E 076^0 56' 54.2 "	358
8	N 11^0 20' 16.9"	E 076^0 55' 51.5 "	365
9	N 11^0 20' 16.4"	E 076^0 55' 42.2 "	374
10	N 11^0 20' 17.4"	E 076^0 55' 34.2 "	366
11	N 11^0 20' 15.7"	E 076^0 55' 25.5 "	360
12	N 11^0 20' 28.3"	E 076^0 55' 44.76"	403
13	N 11^0 20' 13.18"	E 076^0 55' 30.4 "	336
14	N 11^0 21' 14.9"	E 076^0 57' 30.4	364
15	N 11^0 21' 23.46"	E 076^0 57' 50.8 "	344

C) Chemical analysis

The parameters like organic carbon, bulk density, EC were analysed. The organic carbon content of the soil samples was determined following the wet oxidation method (Walkley and Black 1934). The EC was determined by the conductivity bridge instrument.

D) Enumeration of of Bacterial , Fungal and Actinomycetes Population

Enumeration of bacteria

The bacteria were enumerated by plating one ml of 10^{-5} dilution in the sterile Petri plate using Nutrient Agar medium Colonies appearing on the plate on second day were counted and the population was expressed as number of Cfu's/ g soil.

Enumeration of Actinomycetes

One ml of 10^{-4} dilution was transferred to sterile petri dishes and plated in Ken Knight's Agar medium and incubated. The colonies of actinomycetes that appeared after 10-14 days were counted and expressed as number of Cfu's/ g soil.

Enumeration of fungi

Fungi were enumerated by plating one ml of 10^{-3} dilution in the sterile Petri plate using Martin's Rose Bengal Agar medium. The colonies appearing on the plate after 2-3 days of incubation were counted and expressed as number of Cfu's/ g soil.

E) Statistical analysis.

Results were analyzed using analysis of variance (ANOVA). Comparisons between groups for a significant difference of mean values were performed after normality and variance tests. The correlation was performed with SPSS software for Windows. The regression analysis was carried out by using MaxStat software.

Results and Discussion

Table 2. Organic carbon, Bulk density, EC of the soil samples

Soil Sample	Organic carbon (%)	Bulk density (g/cm^3)	EC (ds/m)
1	0.21	1.20	0.72
2	0.03	1.33	0.85
3	0.03	1.33	0.83
4	0.12	1.25	0.75
5	0.06	1.25	0.79
6	0.63	1.12	0.54
7	0.36	1.12	0.59
8	0.3	1.17	0.61
9	0.24	1.17	0.7
10	0.54	1.12	0.57
11	0.09	1.25	0.79
12	0.03	1.33	0.83
13	0.24	1.20	0.72
14	0.39	1.12	0.58
15	0.06	1.25	0.79
Mean	0.22	1.214	0.71

The organic carbon ranged between 0.03 to 0.63 %. The highest organic carbon (0.63 %) was found in the soil sample No 6. The bulk density of the soil ranged from 1.12 g/cm^3 to 1.33 g/cm^3. The average organic carbon, bulk density and EC of the soils are, 0.22 %, 1.214 g/cm^3 and 0.71 (ds/m) respectively.

Microbial population of the soil samples

The total population of viable bacteria, actinomycetes and fungi present in the soils were enumerated following serial dilution technique and pour plate method (Parkinson *et al*., 1971).

Table 3. The population of Bacteria, Actinomycetes and Fungi in different soil samples (Expressed as cfu's/g of soil)

Soil Sample	Bacteria ($\times 10^5$)	Actinomycetes ($\times 10^4$)	Fungi ($\times 10^3$)
1	25 ± 2.33	38 ± 1.53	58 ± 2.44
2	13 ± 3.25	23 ±1.99	32 ±3.30
3	13 ± 3.21	25 ±1.90	40 ± 2.95
4	24 ± 2.41	33 ±1.64	51 ±2.61
5	18 ± 2.76	30 ±1.73	46 ±2.73
6	49 ± 1.67	53 ±1.30	89 ±1.96
7	36 ± 1.94	45 ±1.42	75 ± 2.14
8	35 ± 1.98	38 ±1.54	74 ± 2.16
9	30 ± 2.13	39 ±1.53	70 ± 2.22
10	44 ± 1.76	46 ±1.40	90 ± 1.96
11	21 ± 2.58	26 ±1.85	47 ± 2.71
12	14 ± 3.17	22 ±2.04	40 ± 2.93
13	28 ± 2.20	36 ±1.58	65 ± 2.30
14	43 ± 1.79	45 ±1.42	77 ± 2.11
15	21 ± 2.58	28 ±1.78	47 ± 2.72
Mean	28	35	60

The total viable bacteria, actinomycetes and fungi of the soils were obtained at 10^5,10^4 and 10^3 dilutions respectively. The average population of bacteria, actinomycetes and fungi values are 28, 35 and 60 respectively

Table 4. Correlation coefficient (r) between Bulk density, Organic carbon, EC and microbial population in the soil

	Organic carbon	Bulk density	EC	Bacteria	Actinomycetes	Fungi
Organic carbon	1	-	-	-	-	-
Bulk density	-0.901**	1	-	-	-	-
EC	-0.959**	0.956**	1	-	-	-
Bacteria	0.977**	-0.953**	-0.984**	1	-	-
Actinomycetes	0.956**	-0.954**	-0.962**	0.967**	1	-
Fungi	0.965**	-0.957**	-0.975**	0.980**	0.957**	1

**. Correlation is significant at the 0.01 level (2-tailed)

The results indicate that organic carbon, bulk density and EC of the soil can significantly impact microbial population in the soil. Correlation coefficient between organic carbon and microbes exhibit a significant positive correlation which is r =0.977 (Bacteria), r=0.956 (Actinomycetes), r= 0.965 (Fungi) respectively. The correlation between bulk density and microbes shows the negative relationship which is r= 0.953 (Bacteria) r= 0.954 (Actinomycetes), r=0.957 (Fungi). The EC value of the soil shows negative impact on the microbial population which is r=0.984 (Bacteria), r=0.962 (Actinomycetes),r= 0.975 (Fungi) .The present study is in agree with the observations made by Das *et al* (2013) that soil organic carbon is highly correlated with the bacterial(0.970) and fungal (0.888) population.

Table 5. Regression equation involving soil factors and microbial population

S.No	Factors	Bacteria	Actinomycetes	Fungi
1.	Organic carbon	Y= 59.819 x +14.342, R^2= 0.954	Y= 47.44 3 x + 24.623 , R^2=0.914	Y=93.520x +39.217, R^2 =0.931
2.	Bulk density	Y= -143.218x+201.488, R^2=0.908	Y= -116.123x +176.128, R^2=0.910	Y= -227.63x +336.36, R^2=0.916
3.	EC	Y= -107.971x +104.318, R^2=0.969	Y= -85.487x +95.879, R^2=0.926	Y= -169.163x +180.141, R^2=0.950

Regression equation between Organic carbon and Bacteria, Actinomycetes, Fungi

Figure 1. Organic carbon Vs Bacteria

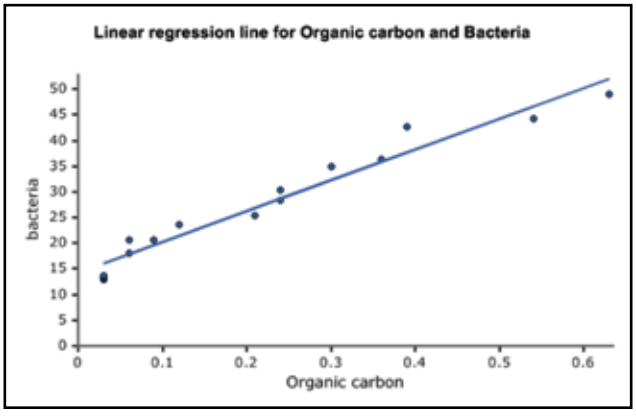


Figure 2. Organic carbon Vs Actinomycetes

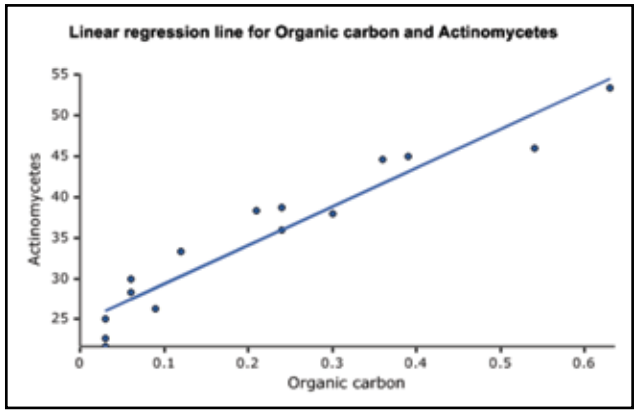
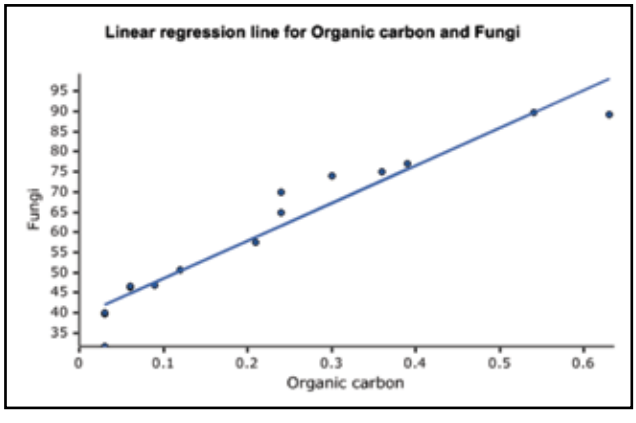


Figure 3. Organic carbon Vs Fungi



The observation from the regression equation of organic carbon with microbial population shows the positive correlation which indicated that, the minimum organic carbon for Bacteria, Actinomycetes and Fungi was 14.342, 24.623 and 39.217 respectively (figure 1,2,3 and Table 5) and Increase of 59.819, 47.443 and 93.520 CFU of Bacteria, Actinomycetes and Fungi occurred per g of soil for every unit increase in organic carbon.

Regression equation between Bulk density and Bacteria, Actinomycetes, Fungi

Figure 4. Bulk density Vs Bacteria

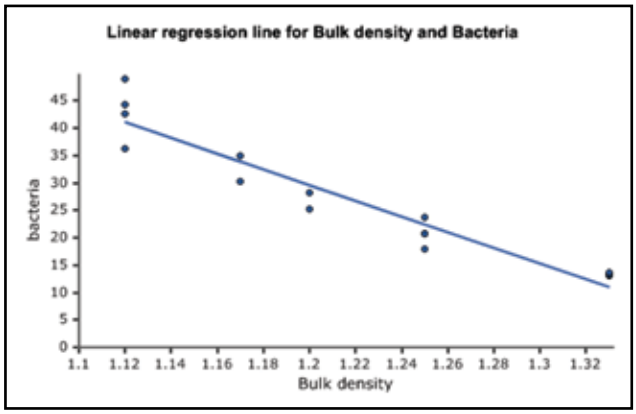


Figure 5. Bulk density Vs Actinomycetes

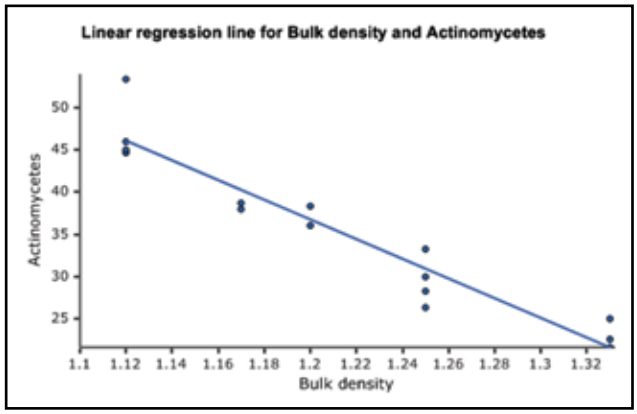
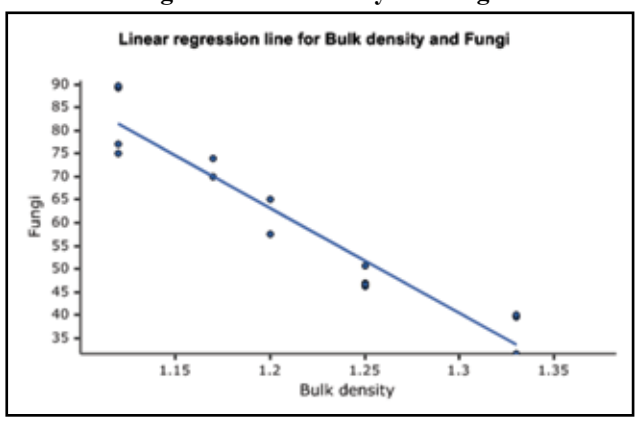


Figure 6. Bulk density Vs Fungi



The observation from the regression equation of bulk density with population of Bacteria, Actinomycetes and Fungi shows the negative correlation which indicates the attainable bulkdensity value was 201.488, 176.128 and 336.36 for population of Bacteria, Actinomycetes and Fungi respectively (Figure 4,5,6 and Table 5) and drop of 143.218, 116.123 and 227.63 population of Bacteria, Actinomycetes and Fungi occurred per g of soil for every unit increase bulk density.

Regression equation between EC and Bacteria, Actinomycetes, Fungi

Figure 7. EC Vs Bacteria

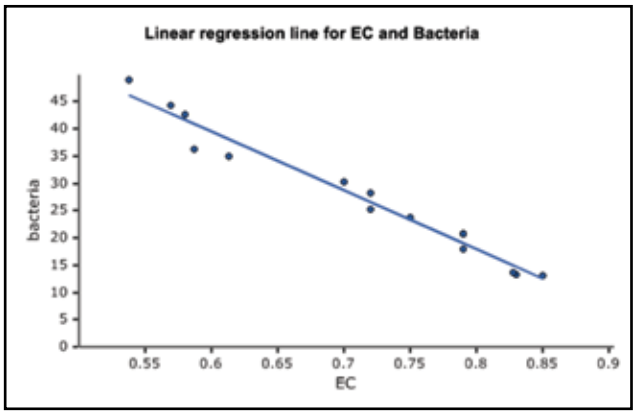


Figure 8. EC Vs Actinomycetes

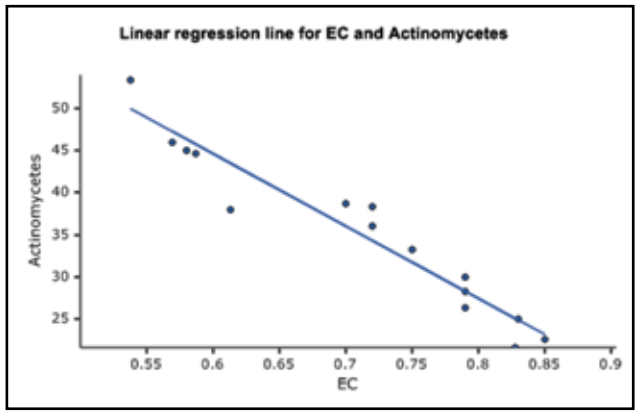
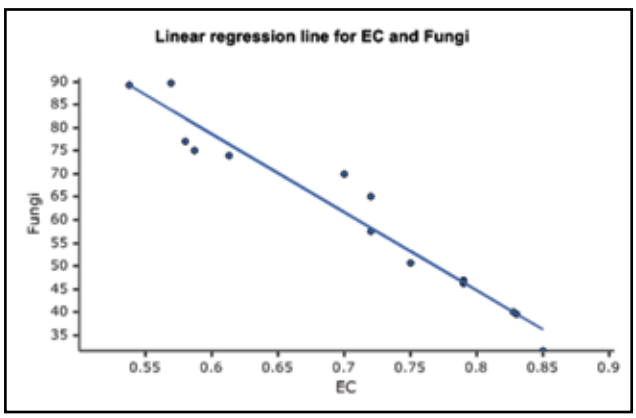


Figure 9. EC Vs Fungi



The observation from the regression equation of EC with population of Bacteria, Actinomycetes and Fungi shows the negative correlation which indicates the attainable EC value was 104.318, 95.879 and 180.141 for population of Bacteria, Actinomycetes and Fungi respectively (Figure 7,8,9 and Table 5.) and drop of 107.971, 85.487 and 169.163 population of Bacteria, Actinomycetes and Fungi occurred per g of soil for every unit increase in EC.

Many factors have been suggested to explain the effects of vegetation type on microbial biomass in soils (Hackl *et al*. 2004). Differences in the quantity and quality of substrate inputs via varying litter and root types and associated nutrient specificity can be crucial drivers to influence the soil microbial biomass (Feng *et al*. 2009; Jin *et al.* 2010). Soil microbial biomass greatly depends on soil organic matter as substrate; a decrease in soil organic carbon causes reduction in soil microbial biomass (Chen *et al*. 2005). The distribution of soil microbial population is determined by a number of environmental factors like pH, moisture content and soil organic matter (Kennedy *et al*. 2005). This study is ensuring that the microbial population is highly influenced by the soil organic carbon, bulk density and EC.

Conclusion

The present study concludes that the population of Bacteria, Actinomycetes and Fungi in the tropical thorn forest of jackanari reserve forest soils are influenced by soil physical and chemical properties such as bulk density, organic carbon and EC. Our results showed that increases in soil organic carbon has increased the population of bacteria, actinomycetes and fungi. An increase in soil bulk density has reduced the population of bacteria, actinomycetes and fungi.

However, the role of macro and microclimatic seasonality cannot be completely ruled out. It is also understood that the quality of plant residues accumulating in these sampling sites are furthermore important and may play a vital role in soil nutrient management within the system through microbial decomposition. Documentation and conservation of biodiversity including microbial diversity is important as it provides the potential source of biological resources.

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