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Seasonal variations in Microbial Diversity in Tropical Dry Deciduous Forest of Central Uttar Pradesh

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ABSTRACT

A study was carried out to examine the regular changes in the nutrient status under different land utilizes of tropical deciduous forest of Central Uttar Pradesh. Dry tropical soils were examined to analyses the seasonal dynamics of microbial biomass carbon, phosphorus and nitrogen. Other soil properties like pH, total organic carbon, total nitrogen, available phosphorus exhibit strong seasonality and comparatively they are higher in forest soils as compared to agricultural soils. At all the sites, the maximum MBC, MBN and MBP occurred during the dry period (summer season) and the minimum in wet period (rainy season). Increased demand for plant nutrients during the rainy season reduced the supply of nutrients to soil microbes and thus low microbial biomass C, N and P. In the present study soil MB-C, MB-N and MB-P were higher at forest sites as compared to agricultural sites. Such findings suggest that the preservation of nutrients by soil microbial biomass was better in the limited logging stand which will lead to the recovery of forest under conservation. The differences in MBC, MBN and MBP were significant (P <0.001) among sites and seasons. The MBC (P < 0.0001), MB-N (P < 0.001) and MB-P (P < 0.0001) were positively correlated with organic C. Therefore, the minimum and maximum microbial biomass C, N and P during the rainy and winter season indicate a balance between a nutrient demand for plant growth and nutrient retention in microbial biomass that will help to recover the environment after disruption.

Keywords: Forest, Organic Carbon, Disturbed sites, deforestation, dry period, wet season

INTRODUCTION

Working of biological systems depends on the flux of chemical signals, carbon, and nutrients over the trophic levels, predominantly interceded by microbial connections in the soil plant-animal food web (Seneviratne, 2015). Soil microbial diversity variety and plenitude/biomass assume key roles in the biological system maintainability by keeping up basic elements of soil health, through carbon and nutrient turnover. Micro-organisms (bacteria, fungi) add to over 90% of the carbon dioxide advanced during decay of forest litter (Schaefer, 1991), showing their role in the component cycling in forest environments.

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Nitrogen is for the most part cycled between primary producers and decomposer biota. The activity and development of micro-organisms rely upon carbon and nutrient flexibly and the physico-chemical environment as a result of their high surface area/volume proportion of microbial bodies (Hattori and Hattori, 1976; Paul and Clark, 1996). Microbial biomass is a little however, labile and living segment of soil natural issue that is associated with most biochemical procedures (Paul and Voroney, 1980). It interfaces with environment efficiency by managing supplement availability, deciding soil C storage and adding to air carbon dioxide from respiration. Support of soil quality is a key segment of sustainability wherein soil microbial biomass was utilized as indicators (Kara and Bolat, 2007; Tóth *et al.,* 2007 and, Kaschuk *et al.,* 2011). Dry and wet seasons are two extrema in tropical biological systems which affect profitability, supplement cycling and microbial biomass. A few investigations detailed occasional inconstancy of microbial biomass, with more substance of soil microbial biomass in both, dry (Maithani *et al.,* 1996 and Montaño *et al.,* 2007) and wet seasons (Devi and Yadava, 2006). Due to the moderate plant growth and nutrient take-up during dry seasons, it has been accounted for that high measure of microbial biomass hold nutrients (Singh *et al.,* 1989). In the rainy seasons, quick plant development and root movement just as exceptional changes in soil dampness invigorate quick turnover of microorganisms (Fierer and Schimel, 2003). This prompts lower microbial biomass substance and expanding CO_2 efflux rates (Otieno *et al.,* 2010; Singh *et al.,* 1989 and Sugihara *et al.,* 2010). Henceforth, it is accepted that in tropical biological systems with a bimodal climatic example soil organisms speak to both a sink and source of nutrients (Srivastava, 1992). The tropical environments are in exceptional concentration due to expanding anthropogenic unsettling influences and diminishing C spending plans (decline in C stocks of 25-30%, Don *et al.,* 2011). Hence in the present study an attempt is made to analyze the soil microbial biomass carbon, nitrogen and phosphorus under two different land uses as well as to examine the seasonal variations in microbial diversity and studied the relationship between MBC, MBP and MBN with physic-chemical properties of soil.

MATERIALS AND METHODS

Study Area

The research was performed in and around Lucknow's Kukrail Reserve Forest, Uttar Pradesh's capital. Lucknow locale is a piece of Central Ganga Plain in the province of Uttar Pradesh covering a zone of 2,528 sq. km. what's more, lies between North scopes 26°30' and 27°10' and East longitudes 80°30 'and 81°13' with all out populace of 34 lakhs according to 2011 enumeration. Kukrail Reserve Forest is situated in Khurram Nagar/Indira Nagar contiguous Shivpuri settlement on an excursion spot street a good way off of 9 km from the focal point of the city. The crocodilians restoration focus was created during 1978 and was liberally subsidized by the Uttar Pradesh forest department. In the past, around 30 years back, it was a highly degraded forest. High biotic pressure, animal grazing, vegetation exploitation and nutrient deposition have created disturbance in the natural succession of the forest. In this manner, species wealth diminished significantly, and predominance was concentrated inside a couple of animal types during the most recent 30 years, when state government gained and preserved the locale as reserve forest. Lucknow- the capital of Uttar Pradesh is a land locked city. The distance from the sea gives Lucknow an extreme type of continental climate with the prevalence of continental air during major parts of the year. Only during the four months from June to September does the air of oceanic origin penetrate to this region and causes increased humidity, cloudiness and rain. About 75% of the total rainfall is realized during these four months. The year can be broadly divided in to four seasons. The cold season starts from December and extends up to end of February. This is followed by the hot weather season which lasts till about first fortnight of June when monsoon arrives over the region. The monsoon continues till September. The two post monsoon months of October and November constitute a transition season from monsoon to winter conditions. Soils in the district exhibit a wide variation in composition texture and appearance.

Geology of the Area

The state can be divided into two regions of physiographic: the central plain of Ganges (Ganga) River and its tributaries (part of indo-Gangetic Plains) and the southern uplands. Uttar Pradesh vast bulk is in the Gangetic plain which is made up of alluvial deposits carried down by the Ganges network from the Himalayas. Most of this region is a featureless, but fertile plain that ranges in height from about 300 m in the northwest to about 60 m in the east. The southern uplands are a part of heavily dissected and rugged Vindhya Range which normally rises to the south east. This regions altitude rarely reaches 300 m. The state is well drained by various waterways beginning in either the Himalayas toward the north or the Vindhya Range to the south. The Ganges and its principle tributaries- *viz.,* the Yamuna, the Ramganga, the Gomati, the Ghaghara furthermore, the Gandak streams- are nourished by the ceaseless snow of the Himalayas. The Chambal, the Betwa and the Ken streams, beginning from the Vindhya Range, channel the southwestern piece of the state before joining the Yamuna. The Son River, also from the Vindhya Mountains, floods the states southeastern potion and enters the Ganges (in Bihar) state boundaries. The general incline of the city territory is from North and Northwest to South and Southeast. The height of the city region differs from 103 to 130 m above mean ocean level. With its characteristics features, this area has three different geomorphic surfaces, namely

i) Younger Flood Plain (T0)
ii) Older Flood Plain (T1)
iii) Interfluve Plain or Upland Area (T2)

Soil Sampling

Soil samples were collected randomly from mainly two sites that are forest and agricultural area. A total of 30 samples were collected from these sites at a depth of about 0-10 cm during each season *i.e.* summer, winter and rainy (KRFA1-KRFA10 agricultural area and KRFF1-KRFF20 forest area). The soil samples were placed in a plastic bag and taken to laboratory for further analysis. Field moist soil was divided into two parts. One part was oven dried and it is used for physico-chemical analyses of soil and the other part *i.e.* the fresh soil was used for analyses of the microbial Biomass.

Soil physical characteristics

Soil physical parameters were done in the air–dried soil. Soil texture (relative proportion of sand silt, clay on a weight basis) was measured by hydrometer method using the protocol of (Bouyoucos, 1927). Bulk density was determined by measuring the weight of soil by Pcynometer (Blake, 1965).

Soil physio-chemical parameters

Soil physio-chemical parameters were carried out in air dried soils which include pH, EC, Total organic carbon (TOC), Total Nitrogen (TN), and Available Phosphorus (AP). Soil pH was measured in 1:4 soils: water suspension using pH meter (Thermo Orion). according. The same soil suspension was used for EC measurement after soil suspension. Available Nitrogen (AN) was measured using Kjeldahl nitrogen (Kjeltech analyser) (Bremner and Mulvaney, 1982). Available Phosphorus was estimated by using a method of (Olsen *et al.,* 1954).

Soil Biochemical Assay

We have assessed Microbial Biomass Carbon (MBC), Microbial Biomass Nitrogen (MBN), Microbial Biomass phosphorus (MBP) under soil biochemical parameters.

Microbial biomass carbon analysis: Microbial biomass carbon was determined from the fresh soil using fumigation and non-fumigation extraction method. 12.5 gm of soil was saturated with purified chloroform for 24 hrs. After fumigation, the soil was extracted with potassium sulphate. In the same way, we extract unfumigated soil. Then from both fumigated and non-fumigated extract of soil, microbial carbon was analyzed using titration method (Vance *et al.,* 1987).

Microbial biomass nitrogen: Microbial biomass nitrogen was determined from the same fresh soil from where microbial carbon has been determined, using the chloroform fumigation method. In brief, 12.5gm of soil was saturated with purified liquid chloroform for 24hrs. After fumigation, the soil was extracted with 0.5M K2SO4 (1:4 soil: extractant) for 30min. In the same way, we extract unfumigated soil. Then from both fumigated and non-fumigated extract of soil total nitrogen was analyzed using Kjeldahl digestion procedure (Brookes *et al.,* 1985).

Microbial biomass phosphorus: Biomass phosphorus was also determined by chloroform fumigation- extraction method 5.5 gm sample of fresh soil was taken in 250ml of the conical flask and saturated with chloroform for 24 hours. In this analysis, chloroform was not removed because its presence prevents microbial growth during extraction and filtration (Brookes *et al.,* 1982).

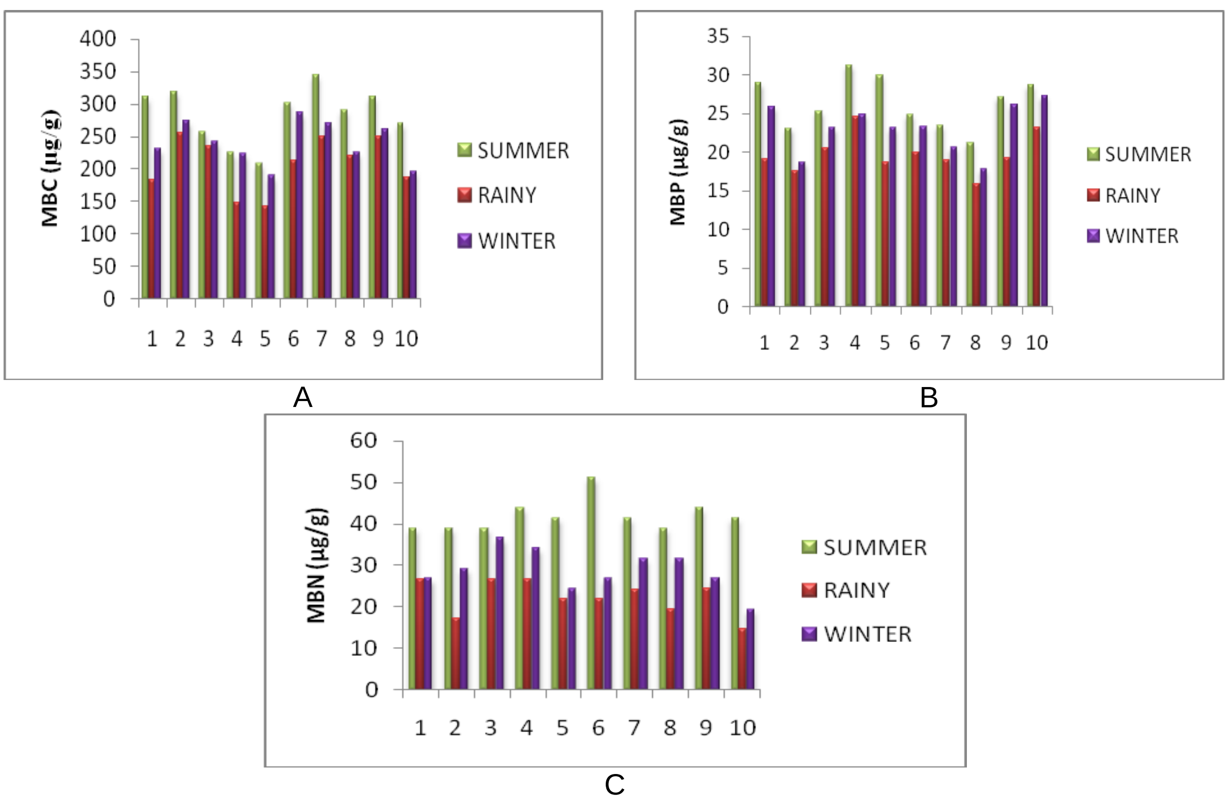
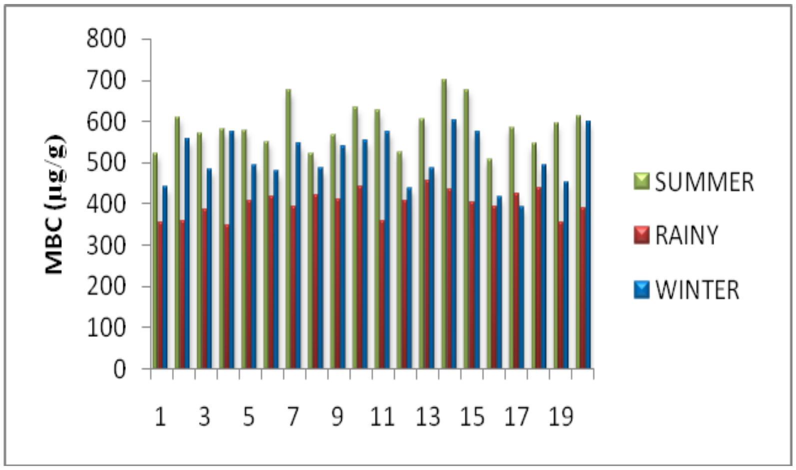


Fig.1: Microbial Biomass Properties in Agricultural Area (A) Microbial Biomass Carbon (MBC) (B) Microbial Biomass Phosphorus (MBP) (C) Microbial Biomass Nitrogen (MBN).



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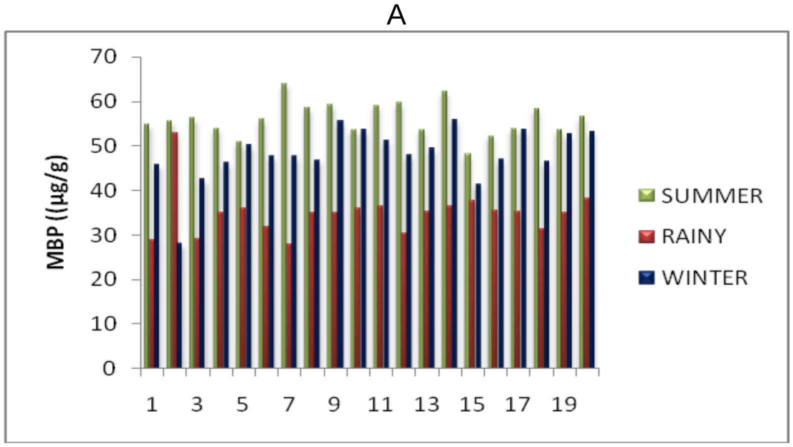

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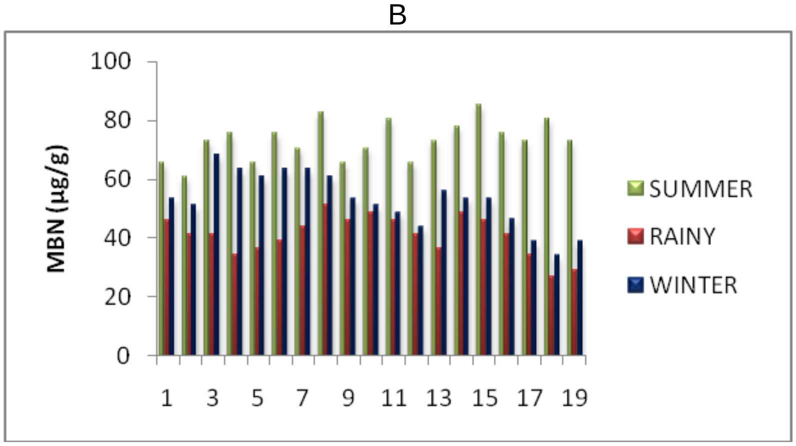

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Fig. 2: Microbial Biomass Properties in Forest Area (A) Microbial Biomass Carbon (MBC) (B) Microbial Biomass Phosphorus (MBP) (C) Microbial Biomass Nitrogen (MBN).

RESULTS AND DISCUSSION

Physico-chemical and biological properties of these soils were significantly different. Results of physico-chemical properties of soil were given in Table-1. The cumulative average value of pH in agricultural area is in the range of 6.15-7.06. Comparison among the three seasons showed that in summer seasons pH value ranges between 6.83-7.06, in rainy season it ranges between 6.15-6.46 and in the winter season between 6.37-6.55. The study reveals that in summer season maximum pH was observed with average value of 6.93 and the minimum pH was observed with value 6.26 in rainy season. Soil pH under all the two diverse lands utilizes followed a similar example as it was watched higher in summer followed by winter and the least was seen in rainy separately. All the soil texture was in the order of sand> silt> clay. Bulk density (BD) in forest soils ranges between 1.24-1.38 g cm^{-3} and in agricultural soil ranges between 1.22-1.36 g cm^{-3}. The maximum value of BD is in summer and least in winter. The winter condition faces the minimum value of bulk density probably due to the freez-thaw condition in these soils. The cumulative average value of EC in agricultural area is in the range of 99.46-156.85 µS. Comparison among the three seasons showed that in summer seasons EC value ranges between 143.66-156.85 µS, in rainy season it ranges between 99.46-142.20 µS and in the winter season between 110.17-135.11 µS. The cumulative two yearly average value of EC in forest area is in the range of 82.78-125.62 µS. Maximum EC was observed in summer season and minimum in rainy season. The outcomes revealed that the organic carbon content followed same pattern under all the two diverse land utilizes *i.e.,* higher in winter (1.03-1.11%) followed by rainy (0.48-0.80%) and least was seen in summer (0.31-0.46%). The outcomes demonstrated that the greatest level of OC was seen under normal forest during winter season (1.11-1.38%) and the minimum was seen under agricultural area in the summer season (0.31-0.46%). Declining pattern throughout the summer season might be on the grounds that natural carbon content decreases with increase in temperature (Albrecht and Kirschbaum, 1995) (Table-1). The result uncovered in (Table-2) that the available phosphorous under natural forest in winter season was higher (117.64µg/g) followed by rainy (37.78 µg/g) and the least was in summer (24.85 µg/g) separately. The results showed that the highest levels were observed during the winter season in the natural forest and the lowest was observed during the summer season in the agriculture area (Table-1). According to the findings the Available potassium in both the different land uses follows the same pattern that is higher in winter and lesser in summer. Total nitrogen in agricultural soil ranges between 0.082-0.147% and in forest soil between 0.125- 0.156%.

In agricultural soil Microbial biomass Carbon, Nitrogen and Phosphorus ranged from 141.64-343.61µg/g; 14.58-51.09 µg/g and 15.78-31.25% respectively (Table-2). In forest soil it ranged from 347.21-698.69 µg/g, 26.75-85.15 µg/g and 28.04-63.92 µg/g respectively (Table-3). Seasonally Microbial biomass Carbon, Nitrogen and Phosphorus was noted to be maximum in summer followed by winter and minimum in rainy in both the land uses (Table-2, 3) (Fig-1 and Fig-2). This may be due to the higher immobilization of nutrients by microbes from the decomposing litter as decomposition rates of litter and microbial activity are at peak during this period. Further, the growth of fungi also increased during this season due to high relative humidity and this contributes to the soil microbial biomass (Anis and Arya*.,* 2019). The low ranges of MB (Microbial biomass) in current research all through rainy season compared to dry period (summer, winter) may be because of more turnover rate of soil microorganisms and the peak growth of dominant vegetation in wet period (rainy season). Thus during the moist period and in the immediate post monsoon period, the high demand for available nutrients through vigorously growing plant life may restrict the availability to nutrients to competing to soil microorganisms resulted in the low quantity of MB in the rainy season (Singh *et al.,* 2010). Ross *et al.* (1984) have recorded high value of carbon in dry soil. Availability of soil moisture during summer was minimal at both the sites leading to the removal of herbaceous vegetation, degraded forest (Singh *et al.,* 2010). This collectively brought about the minimal competition between microbes and flora in all land use- type and may be the reason for high accumulation and less dynamic and extra dormant microbial biomass. By contrast, Devi and Yadava (2006) reported high soil microbial biomass during the rainy season for a subtropical, mixed oak forest, and Singh and Yadava (2006) observed high soil microbial biomass during summer in grassland and agroecosystem but not in the forest.

Table-1: Soil physico-chemical properties in two different sites

			Agricultural Area	**Forest Area**
S. No	**Soil Properties**	**Seasons**		
1	pH	Summer	6.83-7.06	6.15-6.88
		Rainy	6.15-6.46	6.03-6.23
		Winter	6.37-6.55	6.22-6.32
2	Electrical Conductivity (µs/cm)	Summer	143.66-156.85	82.78-125.62
		Rainy	99.46-142.20	82.78-109.37
		Winter	110.17-135.11	90.11-104.75
3	Bulk Density (g cm$^{-3)}$	Summer	1.27-1.37	1.31-1.38
		Rainy	1.20-1.36	1.29-1.37
		Winter	1.22-1.34	1.22-1.32
4	Total Organic Carbon (%)	Summer	0.31-0.46	0.36-0.51
		Rainy	0.48-0.80	0.85-1.00
		Winter	1.03-1.11	1.11-1.38
5	Available Phosphorus(µg/gm)	Summer	12.71-20.64	21.29-26.89
		Rainy	22.01-27.78	36.50-38.95
		Winter	50.82-65.35	107.08-123.50
6	Total Nitrogen (%)	Summer	0.082-0.124	0.125-0.143
		Rainy	0.082-0.149	0.136-0.143
		Winter	0.143-0.149	0.149-0.156

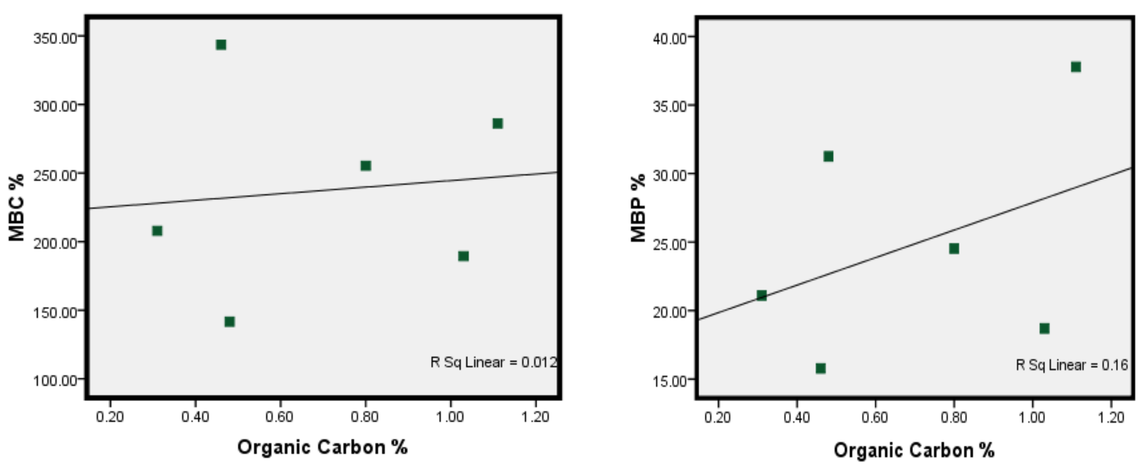
Table-2: Seasonal Difference in Microbial Biomass properties at agricultural site

	Sample Code	Latitude	Longitude	MBC	MBN	MBP	MBC	MBN	MBP	MBC	MBN	MBP
				SUMMER			RAINY			WINTER		
1	KRFA1	26°54'24.87"N	80°59'28.41"E	310.00	38.92457	28.93	183.16	26.75	19.06	230.85	26.75	25.88
2	KRFA2	26°54'23.80"N	80°59'27.40"E	318.64	38.92409	23.08	255.34	17.02	17.51	273.10	29.19	18.70
3	KRFA3	26°54'23.53"N	80°59'28.44"E	257.02	38.92506	25.26	234.60	26.75	20.54	241.97	36.49	23.12
4	KRFA4	26°54'24.39"N	80°59'29.06"E	224.78	43.79002	31.25	147.33	26.75	24.53	222.96	34.05	24.91
5	KRFA5	26°55'20.94"N	81° 0'12.72"E	207.91	41.35766	29.96	141.64	21.88	18.71	189.41	24.32	23.12
6	KRFA6	26°54'57.81"N	80°59'54.63"E	302.25	51.09173	24.82	213.29	21.89	19.89	286.19	26.75	23.25
7	KRFA7	26°55'25.26"N	81° 0'26.21"E	343.61	41.35742	23.41	248.95	24.23	18.97	270.34	31.62	20.60
8	KRFA8	26°54'45.87"N	80°59'41.74"E	290.52	38.92409	21.20	219.23	19.45	15.78	225.27	31.62	17.79
9	KRFA9	26°55'27.74"N	81° 0'24.19"E	311.08	43.79124	27.13	250.41	24.32	19.22	261.29	26.75	26.17
10	KRFA10	26°54'37.28"N	80°59'40.74"E	269.97	41.35742	28.68	187.31	14.58	23.22	196.68	19.45	27.28
RANGE				207.91 - 343.61	38.92-51.09	21.10-31.25	141.64 - 255.34	14.58 - 26.75	15.78-24.53	189.41-286.19	19.45-36.49	18.70 - 27.28
AVERAGE				283.57	41.84	26.37	208.12	22.36	19.74	239.80	28.66	23.08
SD				43.15	3.76	3.31	41.77	4.25	2.55	32.17	4.97	3.19

Table-3: Seasonal Difference in Microbial Biomass properties at forest site

	Sample Code	Latitude	Longitude	MBC	MBN	MBP	MBC	MBN	MBP	MBC	MBN	MBP
				SUMMER			RAINY			WINTER		
1	KRFF1	26°54'23.77"N	80°58'58.74"E	522.13	65.68	54.75	355.50	46.22	28.95	440.37	53.52	45.83
2	KRFF2	26°54'13.41"N	80°58'51.88"E	609.50	60.82	55.48	358.88	41.35	52.85	554.95	51.08	28.04
3	KRFF3	26°54'22.18"N	80°58'49.06"E	569.46	72.98	56.28	385.29	41.35	29.09	483.11	68.12	42.45
4	KRFF4	26°54'27.07"N	80°58'53.45"E	578.68	75.42	53.93	347.21	34.05	34.97	575.13	63.25	46.29
5	KRFF5	26°54'43.22"N	80°59'4.72"E	577.47	65.68	51.00	405.64	36.49	35.87	493.66	60.82	50.17
6	KRFF6	26°54'56.94"N	80°59'10.00"E	550.51	75.42	55.94	417.48	38.92	31.72	477.67	63.25	47.63
7	KRFF7	26°55'7.36"N	80°59'9.07"E	672.97	70.55	63.92	393.30	43.78	27.89	543.84	63.25	47.67
8	KRFF8	26°55'18.30"N	80°59'14.14"E	520.89	82.72	58.41	422.04	51.09	35.08	485.11	60.82	46.67
9	KRFF9	26°55'21.80"N	80°59'10.44"E	564.76	65.68	59.18	409.30	46.22	34.98	539.22	53.52	55.57
10	KRFF10	26°55'28.79"N	80°59'20.62"E	631.26	70.55	53.59	441.83	48.65	36.00	552.25	51.08	53.59
11	KRFF11	26°55'34.17"N	80°59'28.30"E	624.10	80.28	59.08	358.46	46.22	36.49	573.99	48.65	51.25
12	KRFF12	26°55'20.40"N	80°59'40.17"E	524.65	65.68	59.59	407.04	41.35	30.44	438.43	43.78	47.96
13	KRFF13	26°55'17.12"N	80°59'46.88"E	605.38	72.98	53.66	454.08	36.48	35.14	487.62	55.95	49.33
14	KRFF14	26°55'27.75"N	80°59'54.80"E	698.69	77.85	62.26	436.12	48.65	36.39	601.89	53.52	55.88
15	KRFF15	26°55'22.80"N	80°59'47.98"E	675.92	85.15	48.09	404.03	46.22	37.66	574.20	53.52	41.39
16	KRFF16	26°55'27.50"N	80°59'45.94"E	508.76	75.42	52.07	394.28	41.35	35.61	416.97	46.22	46.88
17	KRFF17	26°55'38.55"N	80°59'57.07"E	583.68	72.98	53.93	422.47	34.05	35.25	393.75	38.92	53.69
18	KRFF18	26°55'41.36"N	80°59'59.27"E	544.08	80.28	58.25	438.78	26.75	31.40	492.46	34.05	46.39
19	KRFF19	26°55'52.08"N	80°59'46.44"E	592.77	72.98	53.61	354.23	29.19	34.89	451.09	38.92	52.50
20	KRFF20	26°55'45.16"N	81° 0'20.21"E	611.67	63.25	56.51	388.71	31.62	38.21	597.91	34.05	53.18
RANGE				508.76-698.69	60.82-85.15	48.09-63.92	347.21-454.08	26.75-51.09	28.95-52.85	393.75-601.89	34.05-68.12	28.04-55.88
AVERAGE				588.36	72.61	55.97	399.73	40.5	34.94	508.68	51.81	48.11
SD				53.94	6.71	3.81	32.16	6.89	5.17	62.18	10.05	6.21

In agricultural site MBC, MBP and MBN were positively correlated with organic carbon (Fig-3) P<0.001, P<0.001 and P<0.001 respectively. Similarly, in forest site also MBC, MBP and MBP were positively correlated with organic carbon (Fig-4) which indicated that Microbial Biomass is highly influenced by the presence of organic carbon. Regression analyses were performed to predict the variation between two soil parameters at two different sites. The results were represented in scatter plot which represented the association between the two different variables.



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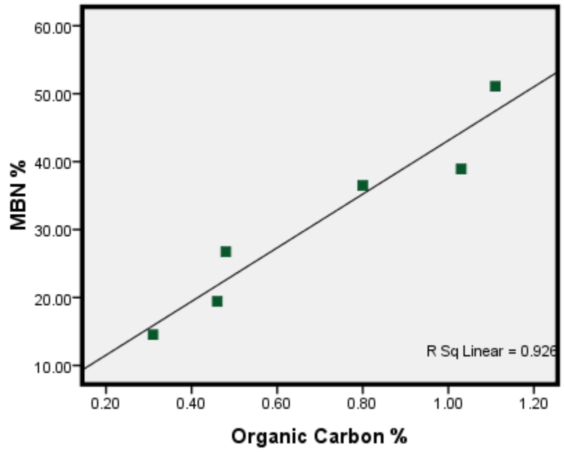

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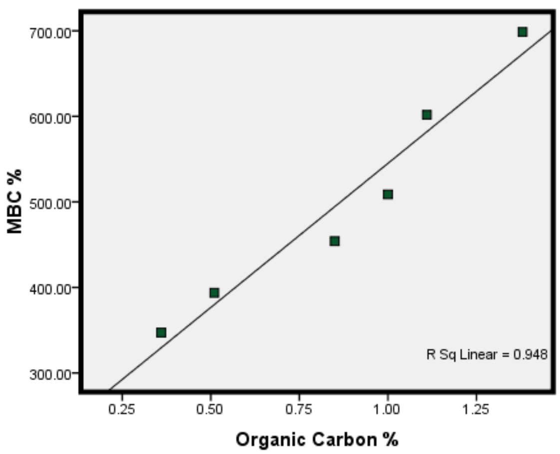
Fig. 3: Relationship between Soils Organic Carbon in agricultural area (A) Microbial Biomass Carbon (MBC) (B) Microbial Biomass Phosphorus (MBP) (C) Microbial Biomass Nitrogen MBN).



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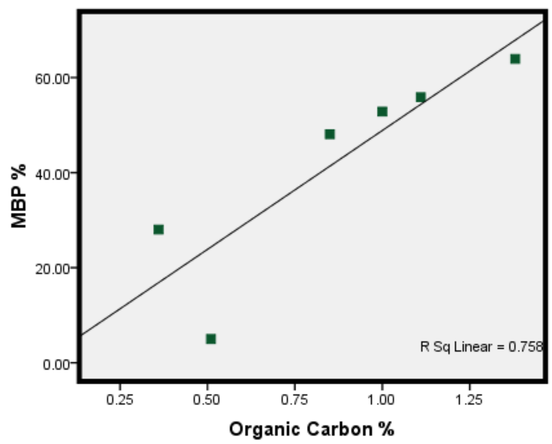

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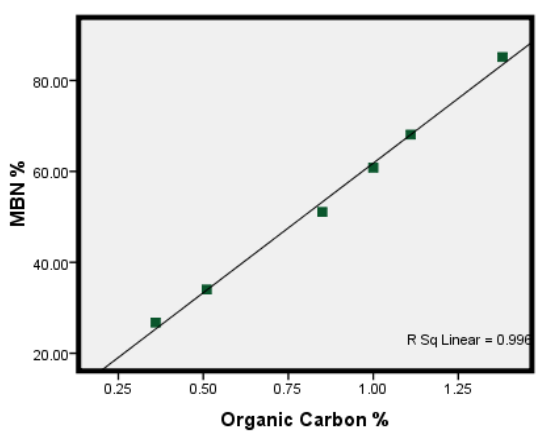

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Fig.4: Relationship between Soils Organic Carbon forest area (A) Microbial Biomass Carbon (MBC) (B) Microbial Biomass Phosphorus (MBP) (C) Microbial Biomass Nitrogen (MBN).

At agricultural site between MBC and organic carbon R square value is 0.012, MBP and organic carbon is 0.16 and MBN and organic carbon is 0.926. Likewise, in forest area R square value between MBC and organic carbon, MBP and organic carbon and MBN and organic carbon is 0.948, 0.758 and 0.996 respectively.

The present investigation showed comparatively low level of MBC, MBP and MBN at agricultural site relative to forest site. This situation might rise because the conversion of forest into agricultural area has resulted in the decrease in plant biomass and caused reductions in organic carbon and different nutrients, which include microbiological properties and accordingly a lower in the amount of microbial biomass, could not be ruled out. According to Srivastava and Singh (1989) decrease in soil nutrients and microbial properties reflect the decline in plant biomass (which is considered to be the chief source of organic nutrients in natural ecosystems) in agricultural area as compared to forest sites.

CONCLUSION

Thus, it may be concluded that MBC, MBN and MBP exhibit strong seasonality, representing minimum during rainy season and maximum during summer season. Organic carbon, soil texture and other soil physical or chemical properties were the key factors affecting the MB (microbial biomass) in tropical dry deciduous forest of central Uttar Pradesh. Soil MB decreases with decline in soil organic content. The decline in MBC, MBN and MBP occurred in all soils of agricultural area as compared to forest site due to extensive forest clearing, overgrazing at former site. Thus the concentration and turnover of microbial biomass has been reported to have intense effect on C and N cycling in such ecosystems. Overall, such studies will a greatly assist in scheming restoration strategy.

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