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Depth wise variation of microbial load in the soils of midland region of Kerala: a function of important soil physicochemical characteristics and nutrients

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Abstract

Soil microorganisms play a main part in organic matter decomposition and are consequently necessary to soil ecosystem processes maintaining primary productivity of plants. In light of current concerns about the impact of cultivation and climate change on biodiversity and ecosystem performance, it is vital to expand a complete understanding of the microbial community ecology in our soils. In the present study we measured the depth wise profile of microbial load in relation with important soil physicochemical characteristics (soil temperature, soil pH, moisture content, organic carbon and available NPK) of the soil samples collected from Mahatma Gandhi University Campus, Kottayam (midland region of Kerala). Soil cores (30 cm deep) were taken and the cores were separated into three 10-cm depths to examine depth wise distribution. In the present study, bacterial load ranged from 141×10^5 to 271×10^5 CFU/g (10cm depth), from 80×10^5 to 131×10^5 CFU/g (20cm depth) and from 260×10^4 to 47×10^5 CFU/g (30cm depth). Fungal load varies from 124×10^3 to 27×10^4 CFU/g, from 61×10^3 to110×10^3 CFU/g and from 16×10^3 to 49×10^3 CFU/g at 10, 20 and 30 cm respectively. Actinomycetes count ranged from 129×10^3 to 60×10^4 CFU/g (10cm), from 70×10^3 to 31×10^4 CFU/g (20cm) and from 14×10^3 to 66×10^3 CFU/g (30cm). The study revealed that there was a significant difference in the depthwise distribution of microbial load and soil physico-chemical properties. Bacterial, fungal and actinomycetes load showed a decreasing trend with increasing depth at all the sites. Except pH all other physicochemical properties showed decreasing trend with increasing depth. The vertical profile of total microbial load was well matched with the depthwise profiles of soil nutrients and organic carbon that is microbial load was highest at the soil surface where organics and nutrients were highest.

Keywords: Soil; Bacteria; Fungus; Actinomycetes.

Introduction

Soil is basic and unique; it control plant productivity of terrestrial ecosystems and it maintains biogeochemical cycles since microorganisms in the soil degrade almost all organic compounds. The living population inhabiting soil includes macrofauna, mesofauna, microfauna and microflora. 80–90% of the processes in soil are mediated by microbes (Nannipieri and Badalucco, 2003). Numerous ecological factors, for example carbon and energy sources, mineral nutrients, growth factors, ionic composition, available water, temperature, pressure, air composition, pH, oxidation–reduction potential and interaction between microorganisms can able to affect the ecology, activity and population dynamics of microorganisms in soil. These environmental factors can vary distinctly, and so microhabitats in soil are dynamic systems.

Most information on microbial biomass, community composition, and diversity comes from studies of surface soil. In the present study we measured the depth wise profile of microbial load in relation with important soil physicochemical characteristics (soil temperature, soil pH, moisture content, organic carbon and available NPK) of the soil samples collected from Mahatma Gandhi University Campus, Kottayam (midland region of Kerala).

Materials and methods

Study area

The study was carried out with soil samples collected from Mahatma Gandhi University campus.

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Tale b1. Depth wise variation of physico-chemical properties of soil in the Manjium plantation of the Campus

Depth of sample (cm)	Soil Temperature (°C)	Moisture Content (%)	pH	Organic Carbon (%)	Available Potassium (Kg/ha)	Available Phosphorous (Kg/ha)	Available Nitrogen (Kg/ha)
10	30	21	5.3	5.097	6.72	0.506	224
20	30	19	5.19	2.536	3.36	0.413	168
30	28	18	5.29	1.487	3.36	0.313	140

The Mahatma Gandhi University lies between 9º39'28"N latitude and 76 º32'10"E longitude. The elevation ranges from 95-151m above mean sea level (MSL). The campus has a total area of 41.75 hectares and is having garden lands, scrub lands, Manjium plantation etc. The campus has also a number of small water bodies (natural as well as man-made) such as quarry, check dam, ponds and wells.

Collection of Sample

Soil samples were collected from prefixed 3 sites of Mahatma Gandhi University campus during pre monsoon season. The selected sites are 1) Manjium plantation (MP), 2) Banks of Check dam (CD), 3) Play Ground (GR). Soil cores (30 cm deep) were taken using metal core and the cores were separated into three 10-cm depths to examine depth wise distribution.

Isolation and Enumeration microorganisms

Isolation and enumeration of bacteria, fungi and actinomycetes were carried by standard serial dilution plate technique. 10 g of soil was transferred to in 90 ml sterile distilled water and agitated vigorously. Different aqueous dilutions, 10^{-1} to 10^{-7} of the suspensions were prepared and spread plated on Soil extract agar, Potato malt agar and Kusters Agar for bacteria, fungus, actinomycetes respectively. For determining the load of microorganisms in the sample, colony forming units were determined by the formula 'No. of microorganisms per gram of sample = No. of colonies × dilution factor'.

Physicochemical characteristics of soil

Temperature was determined in situ with the help of mercury bulb thermometer. Soil moisture content was determined by gravimetric method. pH of soil samples were determined potentiometrically using soil pH meter. Total Nitrogen in the soil samples was determined by Microkjeldahl method (Jackson, 1973). The available phosphorus was estimated by Bray and Kurtz method (Jackson, 1973). The available potassium in the soil samples were extracted using neutral normal ammonium acetate as extractant and determined by using flame photometer (Morgan, 1941). The organic carbon was determined by Walkey and Black Method (Jackson, 1973).

Results

Depth wise variation of soil physico-chemical characteristics

Table 2. Depth wise variation of physico-chemical properties of soil near check dam of the Campus

Depth of sample (cm)	Soil temperature (°C)	Moisture Content (%)	pH	Organic Carbon (%)	Available Potassium (Kg/ha)	Available Phosphorous (Kg/ha)	Available Nitrogen (Kg/ha)
10	32	14	5.37	4.048	5.6	0.358	168
20	31	14	5.38	3.853	4.48	0.313	140
30	30	11	5.63	2.829	3.36	0.179	140

Table 3. Depth wise variation of physico-chemical properties of soil in the play ground of the campus

Depth of sample (cm)	Soil temperature (°C)	Moisture Content (%)	pH	Organic Carbon (%)	Available Potassium (Kg/ha)	Available Phosphorous (Kg/ha)	Available Nitrogen (Kg/ha
10	38	20	5.32	2.453	2.24	0.337	224
20	36	21	5.59	1.658	2.24	0.337	140
30	34	19	5.66	1.06	1.12	0.291	56

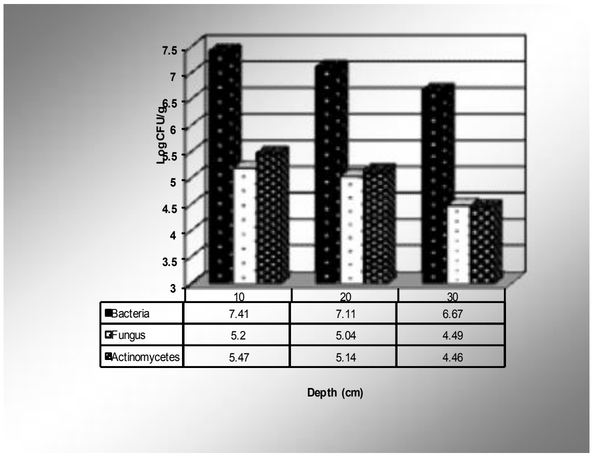

Fig. 1. Depth wise variation of soil microbial load in the Manjium plantation of the Campus

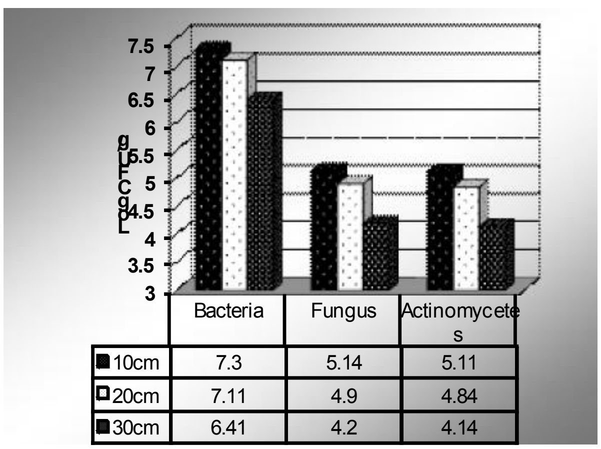

Fig. 2. Depth wise variation of soil microbial load near Check Dam of the campus

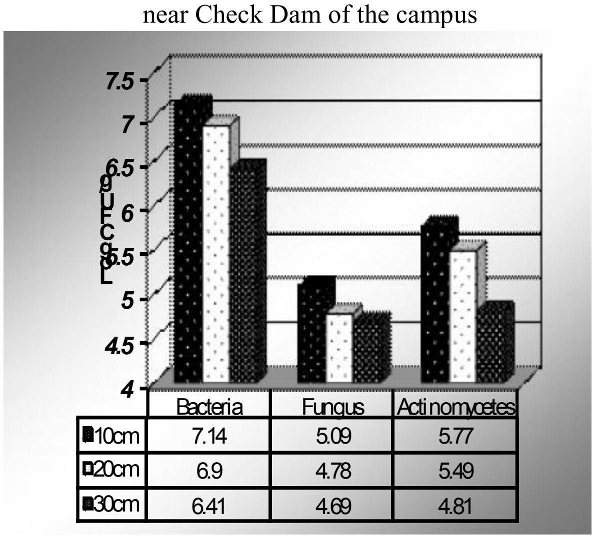

Fig. 3. Depth wise variation of soil microbial load in Play Ground of the Campus

Study revealed that the soil temperature was maximum at GR-10cm (38ºC) and lowest temperature was at MP-30cm (28 ºC). High soil moisture content of 21% was observed at MP-10cm and GR-20cm, and lowest value of 11% was at CD-30cm. The highest pH of 5.66 was recorded from GR-30cm and lowest value of 5.19 was at MP-20cm. The maximum percentage of organic carbon was observed from MP-10cm (5.097%) and lowest percentage of 1.09 at GR-30cm. The highest value of available potassium was at MP-10cm and it was 6.72kg/h and the lowest value of 1.12kg/h was recorded GR-30cm. The maximum value of available phosphorous was at MP-10cm and it was 0.506kg/ha and the lowest value was 0.179 kg/ha at CD-30cm. Available nitrogen was highest at MP -10 and GR-10cm (224 kg/ha) and lowest value of 56 kg/ha at GR-30cm. With increasing depth there was a decreasing trend of organic carbon and NPK were observed (Table 1, 2 and 3).

Depth wise variation of microbial load

In the present study, bacterial load ranged from 141×10^5 to 271×10^5 CFU/g (10cm depth), from 80×10^5 to 131×10^5 CFU/g (20cm depth) and from 260×10^4 to 47×10^5 CFU/g (30cm depth). Fungal load varies from 124×10^3 to 27×10^4 CFU/g, from 61×10^3 to110×10^3 CFU/g and from 16×10^3 to 49×10^3 CFU/g at 10, 20 and 30 cm respectively. Actinomycetes count ranged from 129×10^3 to 60×10^4 CFU/g (10cm), from 70×10^3 to 31×10^4 CFU/g (20cm) and from 14×10^3 to 66×10^3 CFU/g (30cm). The study revealed that there was a significant difference in the depth wise distribution of microbial load. Bacterial, fungal and actinomycetes load showed a decreasing trend with increasing depth at all the sites (Figs. 1, 2 and 3).

Discussion

In soil samples from various depths, the parameters such as NPK, soil organic carbon, temperature and moisture content showed a decreasing trend. The main reasons behind these reductions are low organic matter input, low microbial activity, reduced exposure to sunlight etc., with increasing depth. Depth wise profiles of all parameters were very similar except pH. Organic matter content profile could be the key for explanation for all other parameters. The amount and the rate of degradation of organic matter will leads to change in organic carbon, NPK etc.

Moisture content was also showed decreasing with increasing depth. Some researchers reported that moisture content was constant with increasing depth (Sait *et al.*, 2002), whereas others have reported mixed profiles (i.e., increasing or decreasing moisture with depth) dependent on the types of field cover (Schulze *et al.*, 1996). Schulze *et al*. (1996) measured volumetric water content (%) from five sites with distinctly different soil covers (from desert to forest) on a 140-km transect in Argentina and concluded that there was decreasing trend of soil moisture content is probably caused by the existence of root zone, which extended up to 13 – 18 cm. Another causal factor would be the higher relative concentration of clay and organic matter could hold ample amount of moisture in the upper horizon minimizing downward infiltration and evaporation of the moisture. Acidic pH at the surface layer may be due to appropriate moisture content and the comparatively high organic matter content near surface profile. Organic matter decomposition can produce carbonic acid, carboxylic acid and inorganic acids (Brady, and Weil, 1999) that causes acidic pH in the region where high organic matter content.

Bacterial, fungal and actinomycetes load showed a decreasing trend with increasing depth in all the sites. The depth wise profile of total microbial abundance was well matched with the vertical profiles of soil nutrients and organic carbon. Microbial number was highest at the soil surface where organics and nutrients were highest. The presence of more plant roots in the top soil has strong effect on the microbial load. Diverse plants species are known to make and discharge dissimilar types of organic carbon compounds (Lynch and Whipps, 1990), and those root exudates are the main carbon and energy source and they are a major controlling factor for the composition of soil microbial communities in the neighborhood of plant roots (Bertin *et al.*, 2003).

The decreasing trend of microbial abundance in the downward direction is commonly seen and is naturally obvious given the fact that majority of soil microorganisms are heterotrophs and that the source of organic compounds is higher at or near the surface. Organic matter, including total carbon content generally decreases from the surface to the bottom of the soil profile. In addition to the quantity of carbon, the carbon quality is also known to be lesser at greater soil depths (Trumbore, 2000). Therefore, the composition of microbial communities might be expected to differ as total quantity and quality of major nutrients are changed. The microbial community in the soil probably is dominated by those heterotrophs that readily utilize labile carbon sources, and as the depth increases microorganisms showing a decreased abundance.

Conclusion

The study concluded that there was a significant difference in the depth wise distribution of microbial load and soil physico-chemical properties in the soils of MG University campus. Bacterial, fungal and actinomycetes load showed a decreasing trend with increasing depth at all the sites. Except pH all other physicochemical properties showed decreasing trend with increasing depth. The vertical profile of total microbial load was well matched with the depth wise profiles of soil nutrients and organic carbon.

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