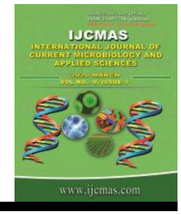
Int.J.Curr.Microbiol.App.Sci (2020) *9*(3): 1739-1745

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 3 (2020)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2020.903.201

Enzyme Activities at Varied Soil Organic Carbon Gradients under Different Land Use Systems of Hassan District in Karnataka, India

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Keywords

Soil Organic Carbon, soil enzyme activities

Article Info

Accepted:
12February 2020
Available Online:
10 March 2020

A B S T R A C T

Most of the biological processes in any soil proceed through enzyme regulated processes. Activities of soil enzymes indicate the soil biological health and it has significant impact on soil fertility improvement. The soil samples from major land uses systems *viz.*, forests (both natural and manmade), coffee, mulberry, coconut, vegetable, potato and paddy land uses systems, were analyzed for soil organic carbon (SOC) and categorized as low (< 0.5 %), medium (0.5-0.75 %) and high (> 0.75 %) SOC soils. Similar soil samples were analyzed for biological properties *i.e*, soil enzyme activities for each category. Dehydrogenase and urease activity were observed higher in soils with higher organic matter status, with trend as low SOC< medium SOC< high SOC. And similar trend was observed for acid and alkaline phosphatase activities.

Introduction

Soil organic matter is a source of essential plant nutrients and acts as a source of food for soil organisms (Woomer *et al.,* 1994; Tan, 2010). The energy requirements of micro and macro organisms, other than autotrophs and chemotrophs, present in the soil are largely met by the organic matter added and the native soil organic matter (Monisa and Tahir, 2018). Soil enzyme activity estimates are often used as indices of microbial activity and soil fertility (Vaughan and Malcolm, 1985; Gianfreda and Bollag, 1996; Ranjith *et al.*, 2015). With this importance the soil organic matter in maintenance of soil biological status, samples from different soil organic carbon (SOC) category were analyzed for soil enzyme activities to know the influence of SOC.

Materials and Methods

Fifteen surface soil samples (0-15 cm depth) from different land use systems *viz.*, forests (both natural and manmade), coffee, mulberry, coconut, vegetable, potato and paddy land uses systems, in Hassan district (Karnataka) were analyzed for soil organic carbon and categorized as low (< 0.5 %), medium (0.5 – 0.75 %) and high (> 0.75 %) SOC soils. Then three samples each from low, medium and high SOC category were analyzed for soil biological properties such as enzyme activities by following standard procedures viz., dehydrogenase (Casida *et al.*, 1964), urease (Watts and Crisp, 1954) and phosphatase (acid and alkaline) activities (Tabatabai and Bremer, 1969).

Results and Discussion

All biochemical activities in soil proceed through enzyme regulated processes and thus, soil enzyme activities can also be used as an index of soil quality. The data pertaining to enzyme activities were presented in Table 1 and 2.

Dehydrogenase and urease activity

The dehydrogenase activity, an index of biological activity, was measured by measuring the red colored TPF formed from TTC reduction. The quantity of TPF formed ranged from 22.4 µg g^{-1} soil 24 h^{-1} in potato soils with low SOC to 36.5 µg g^{-1} soil 24 h^{-1} in coffee plantations with high SOC, indicating least dehydrogenase activity in potato and highest in coffee soils. Agricultural land use systems with high organic matter inputs such as coffee and mulberry recorded higher dehydrogenase activities (Fig. 1).

Urease activity, as expressed by the quantity of urea hydrolyzed, ranged from 56.6 to 76.8 µg g^{-1} h^{-1}. Highest urease activity was recorded in coffee plantations (76.8 µg urea hydrolyzed g^{-1} h^{-1}) while, potato plots were seen with least urease activity (56.6 µg urea hydrolyzed g^{-1} h^{-1}). Urease enzyme was more active in high biomass turnover systems such as coffee and mulberry plantations.

Acid and alkaline phosphatase activity

Acid and alkaline phosphatase enzyme activities were measured by quantifying yellow colored p-Nitrophenol (PNP) compound formed from p-Nitrophenol phosphate (PNP-P). The acid phosphatase activity was found higher (37.5 to 43.4 µg PNP g^{-1} h^{-1}) in natural and manmade forests and coffee plantations. However, agricultural systems recorded lower acid phosphatase values (31.3 to 39.1 µg PNP g^{-1} h^{-1}). The alkaline phosphatase activity was also similar to that of acid phosphatase. However, mulberry soils recorded higher alkaline phosphatase activities among agricultural systems.

Dehydrogenase and urease activity

The dehydrogenase enzyme activity was higher in tree based land use systems while, its activity was found less in agricultural systems. Highest activity was observed in coffee soils with high SOC, while it was least in soils of coconut plantations and vegetable fields. Similar observations on higher dehydrogenase activity in grasslands and forests are reported by Tiwari and others (1988). Among agricultural systems, mulberry soils recorded higher dehydrogenase activity. Many authors have reported similar observations of higher dehydrogenase activity in forest soils (Ajwa *et al.*, 1998; Nagaraja *et* *al.*, 2018) and lesser activity in agricultural soils (Nagaraja *et al.*, 1997; Vidya *et al.*, 2001; Rajeev *et. al.*, 2015). In similar situations, variations in dehydrogenase activities were observed and they were found related to soil organic-C and soil microbial biomass (Martens *et al.*, 1992; Ranjith *et al.*, 2015; Nagaraja *et al.*, 2018). Thus, the addition of organic matter is important in maintaining higher dehydrogenase activities.

Urease activity in different land use systems indicated that the application of organic matter is important in maintaining its activity. Variations in urease activity may be related to vegetation types, quantity of organic residues added and the soil organic matter content (Pacholy and Rice, 1973). Production of higher amounts of urea based compounds in forest soils and addition of nitrogen fertilizers in mulberry and coffee soils might have enhanced urease activity. In other words, the agricultural systems receiving nitrogenous fertilizers with sufficient amounts of organic manures are likely to maintain higher urease activities (Singaram and Kamalakumari, 1995). Similar results of higher urease activity are reported in forests (Vinutha, 2005) and agricultural soils (Siddaramappa and Rao, 1971). Both urease and dehydrogenase were found higher in soils with high SOC contents and they declined with decrease in soil organic matter content. Thus, the maintenance of soil organic matter appears to be very important for both the enzymes.

Table.1 Dehydrogenase and urease activities in soils of different land use systems

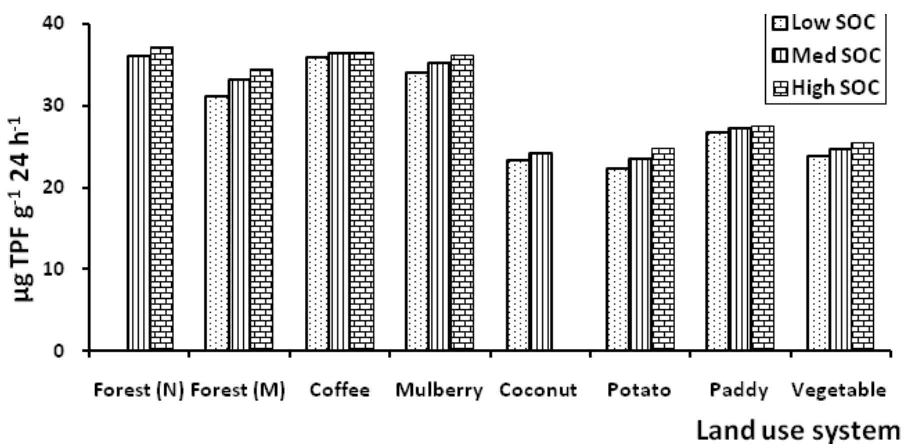
Land use system	Dehydrogenase in soils with (µg of TPF g^{-1} 24 h^{-1})			Urease in soils with (µg urea hydrolyzed g^{-1} h^{-1})		
	Low SOC	Medium SOC	High SOC	Low SOC	Medium SOC	High SOC
Natural forests	-	36.1	37.2	-	64.8	**66.6**
Manmade forests	31.2	33.2	34.5	64.4	65.8	**67.2**
Coffee plantations	36.0	36.4	36.5	75.8	76.1	**76.8**
Mulberry fields	34.1	35.3	36.1	69.7	72.9	**73.0**
Coconut plantations	23.4	24.2	-	60.2	62.4	-
Potato plots	22.4	23.5	24.8	56.6	57.8	**58.2**
Paddy fields	26.8	27.2	27.5	61.3	62.7	**63.9**
Vegetable fields	**23.9**	**24.7**	**25.4**	**66.8**	**67.3**	**68.0**

Note: Categories of low, medium and high SOC soils are based on < 0.50 %, 0.50-0.75 % and > 0.75 % Soil organic-C respectively; Blank cells indicate that there was no representative soil sample in that category
TPF – Triphenyl formazan formed from Triphenyl tetrazolium chloride (TTC)

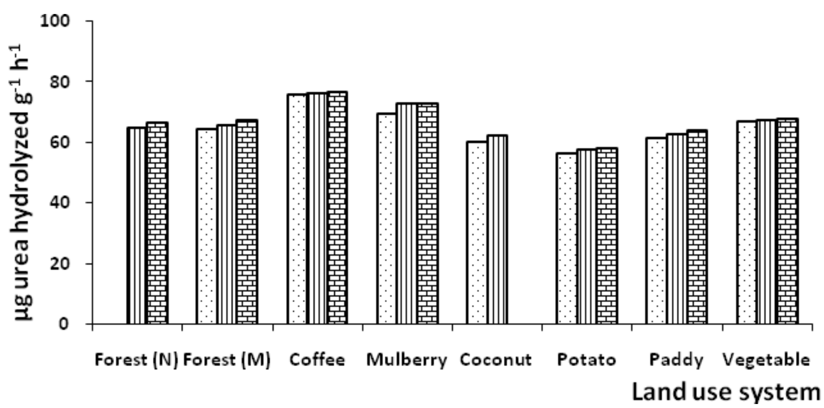
Table.2 Acid and alkaline phosphatase activities in soils of different land use systems

Land use system	Acid phosphatase in soils with (µg PNP g^{-1} h^{-1})			Alkaline phosphatase in soils with (µg PNP g^{-1} h^{-1})		
	Low SOC	Medium SOC	High SOC	Low SOC	Medium SOC	High SOC
Natural forests	-	41.5	43.4	-	17.4	**19.3**
Manmade forests	37.5	38.2	38.6	16.1	16.3	**18.5**
Coffee plantations	40.1	40.4	41.2	17.2	17.5	**20.1**
Mulberry fields	36.2	36.7	39.1	14.6	15.1	**17.6**
Coconut plantations	31.3	33.9	-	13.2	14.4	**-**
Potato plots	32.6	34.4	34.8	13.9	14.7	**17.0**
Paddy fields	34.8	35.4	36.1	14.1	15.7	**17.4**
Vegetable fields	**32.7**	**34.9**	**35.0**	**12.2**	**14.7**	**15.9**

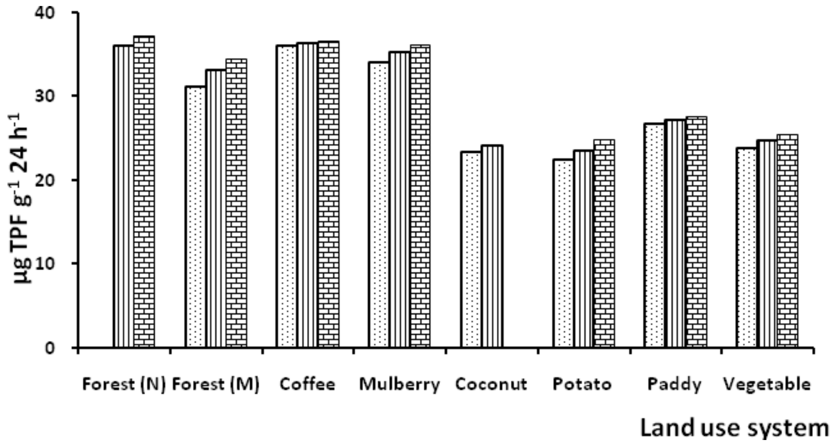
Note: Categories of low, medium and high SOC soils are based on < 0.50 %, 0.50-0.75 % and > 0.75 % Soil organic-C respectively; Blank cells indicate that there was no representative soil sample in that categoryPNP – p-nitro phenol hydrolysed from p-nitro phenol phosphate (PNP-P)



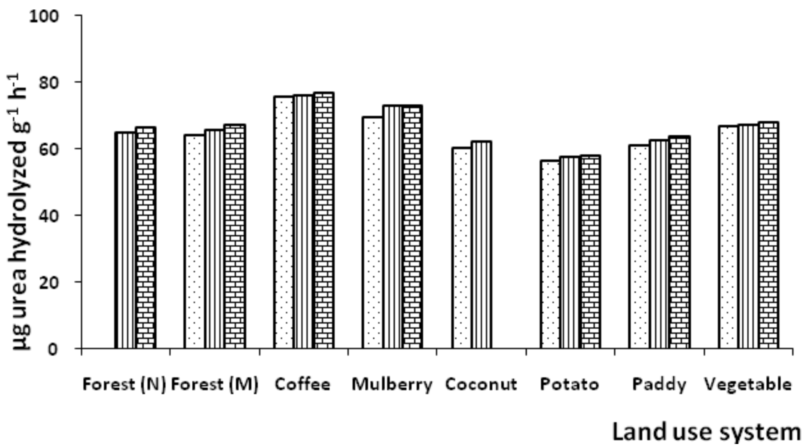
Dehydrogenase activity



Urease activity



Acid phosphatase



Alkaline phosphatase

Fig.1 Dehydrogenase, urease, acid and alkaline phosphatase activities in low, medium and high SOC soils of different land use system

Acid and alkaline phosphatase activity

The phosphatase activities (both acid and alkaline) was found higher in forests (natural and manmade) and coffee plantations. This can be attributed to higher soil organic matter content associated with microbial activity biomass (Rao *et al.,* 1995). The agricultural systems generally recorded lower acid phosphatase activity (Nagaraja *et al.,* 1997). The alkaline phosphatase activities were also higher in forests and coffee plantations, while it was lower in agricultural systems. However, mulberry recorded higher activities of both acid and alkaline phosphatase enzymes. The alkaline condition of mulberry soils might have induced alkaline phosphatase activities. Higher enzyme activity in soils with high SOC (in all land use systems) and in soils of high biomass turnover suggests that the soil organic matter management is important (Vinutha, 2005).

It was observed that the soils with high organic carbon recorded higher enzyme activities (all the four enzymes) compared to soils with low organic carbon. Thus, the enzyme activities among soils with soils with different levels of SOC was in the order of high SOC > medium SOC > low SOC soils.

High biomass turnover tree based land use systems recorded higher enzyme (dehydrogenase, urease and phosphatase) activities. Contrastingly, the agricultural systems supplemented with decomposed forms of organic manures recorded lesser enzyme activities. The enzyme activities among soils with different levels of SOC were in the order of high SOC > medium SOC > low SOC soils. This shows the importance of soil organic matter (SOC) serving as source of energy for soil biological activities.

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How to cite this article:

Sharan Bhoopal Reddy, M. S. Nagaraja, B. C. Mallesha and Kadalli. G. G. 2020. Enzyme Activities at Varied Soil Organic Carbon Gradients under Different Land Use Systems of Hassan District in Karnataka, India. *Int.J.Curr.Microbiol.App.Sci.* 9(03): 1739-1745.
doi: https://doi.org/10.20546/ijcmas.2020.903.201