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Assessment of Carbon Stock in Response to Varied Land Use Systems and Soil Depths in Chandel District, Manipur, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final smanuscript.

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ABSTRACT

To understand the effects of land use system and its cropping techniques, the study on carbon stock and soil nutrients in response to varied land use systems and soil depths in Chandel district was carried out during 2020 from five different locations in the Chandel district that include a variety of land use systems such as Forest area, Jhum cultivation after 15 years, Jhum cultivation after 10 years, Jhum cultivation after 10 years from different sub division of the district, Jhum cultivation after 5 years, Intermittent Jhum area, Oak forest area, Teak forest area, Pine forest area, Agri-horti jhum cropping system area and Maize based cropping system area. The study revealed that Forest soils shows significantly higher Organic carbon content of 2.73 % in 0-15 cm and 2.04% in 30-45

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cm soil depth respectively than the other land use system of Chandel district. Available N was also found to be significantly higher in forest soils i.e. 533.49 kg/ha in 0-15 cm soil depth and 475.14 kg/ha in 30-45 cm soil depth as compared to other land use systems. Similarly, available P_2O_5 of 10.92 kg/ha and 9.97 kg/ha in 0-15 cm and 30-45 cm soil depth respectively and K_2O of 278.08 kg/ha in 0-15 cm and 266.11 kg/ha in 30-45 cm were also recorded to be significantly higher in forest soil which was followed by the Jhum cultivation after 15 years in Chandel district. Next to forest area soils, Jhum cultivation after 15 years shows higher organic carbon content and other soil nutrients as compare to other land use systems due to the longer waiting period of cultivation. These results indicated that the land under more vegetation and less disturbed areas have higher soil nutrient and organic carbon as compared to other land use system. Thus it may be concluded that, variations in soil fertility parameters need immediate improvement in soil health of Jhum lands and other land use systems.

Keywords: Carbon stock; land use system; soil depth.

1. INTRODUCTION

Land use systems involves the management and modification of natural environment or wilderness into built environment as settlements and semi natural habitats such as arable fields, pastures, and managed woodlands. Land-use and land management practices have a major impact on natural resources including water, soil nutrients, plants and animals [1]. Land use changes and management are widely recognized as the most important driving forces of global carbon cycles [2], contribute 6%–39% of the growth in CO_2 emissions [3] and have profound impacts on SOC which are estimated to be one of the second largest sources of human- induced greenhouse gas emissions (1.5 Pg C/a) after fossil fuel combustion (5.3 Pg C/a) [4]. SOC is influenced by dynamic interaction of various factors in the ecosystems including climate, vegetation, soil type, topography, soil texture, soil aggregations, and land use systems. The balance between the rate of decomposition and the rate of supply of organic matter is upset when land use is altered and forests are cleared [5].

Poor soil management and the replacement of native forests by agricultural land may compromise soil health. Soil organic carbon (SOC) is reported as a sensitive indicator of soil quality and environmental sustainability [6]. To sustain fertility and productivity of a soil, SOC is considered essential to improve physical, chemical and biological properties of a soil, as well as it can be used for predicting climate change and effects on crop production. The role of Forests has a great impact on the global biogeochemical cycles and in particular in the carbon cycle. Larger parts of the global C stock are found to be stored in forest ecosystems. About 40% of the total SOC stock of the global soils lies in forest ecosystem and because of their higher organic matter content forest soils are known to be one of the major carbon sinks on earth [7]. It is anticipated that the significant shifts in plant cover will alter the nitrogen cycle and soil C content, affecting sustainability and environmental equilibrium [8]. Conversion of natural forest to other form of land-use can aggravate soil erosion and lead to a reduction in soil organic content and there is a changed in the rates of accumulation, turnover and decomposition of SOC which make changes in SOC [9].

The demand for food and fuel increased along with the district's population growth, and the amount of land available for cultivation decreased. Because of this, both types of traditional farming are becoming more and more changed, overused, and contributing to increased deforestation. Additionally, agricultural productivity is dropping, mostly as a result of the jhum cycle being shorter. Soil, water, and woods are examples of natural resources that have been degraded by both natural and human activity. Similar ecological environments make human-induced land use management strategies the primary factors that influence agricultural productivity and soil qualities. Reducing soil erosion issues at various spatial scales and organizational levels, as well as minimizing the impact of changing land cover on soil parameters, requires effective soil and water conservation methods. In order to slow down the rate of soil deterioration and guarantee the farming system's long-term viability, it is necessary to enhance the qualities of the soil by minimizing changes in land cover through appropriate land management techniques. An essential source of information for evaluating environmental impact is the impact of cropping systems and management strategies on soil parameters. One way to address the issues of ecological imbalance for sustainable crop production is to examine the nutrient status of the soil. Keeping in view, the objectives of this study were to assess the soil properties under varying soil depths of different land use systems in Chandel district of Manipur, India.

2. MATERIALS AND METHODS

To accomplish the objectives of the research problem entitle "Assessment of carbon stock in response to varied land use systems and soil depths in chandel district, manipur" a study was conducted in Chandel district, Manipur. Chandel district is one among 16 districts of Manipur State, India. It is 66 Km north towards state capital Imphal. It lies in the south-eastern part of Manipur between 23.49 and 24.28 North latitude and 94.09 to 94.31 East longitudes. Its neighbors with Myanmar on the East, Tengnoupal district on the north, Kakching district on the west and Churachandpur district to the south. Chandel district occupies an area of approximately 2100 square kilometers. The average annual temperature for Chandel district is 31˚C and experiences summer temperature to the range of 28 to 38.27˚C. The mean annual precipitation varies from 2000 to 2400 mm. The area belongs to warm, humid agro-ecological zone with thermic ecosystem and length of growing period of 300-330 days. The vegetation is predominated by pine including woody and herbaceous species. The soil types of Chandel district are mostly coarser, varying from fine loamy, loamy to sandy in texture and deep in soil depth. Soils of the study area fall under three major soil orders: ultisol, inceptisol and alfisols.

The soil samples were collected from the different land use system namely Forest area from Lambung village, Jhum cultivation after 15 years from Lamphoucharu village, Jhum cultivation after 10 years from Lamphoucharu village, Jhum cultivation after 10 years from Chakpikarong sub division of the district, Jhum cultivation after 5 years from Monsangpantha village, Intermittent Jhum area Phunchung village, Oak forest area from Lambung village, Teak forest area from Tengnoupal Sub division of Chandel district, Pine forest area Lamphoupasna village, Agri-horti jhum cropping system area from Monsangpantha village and Maize based cropping system area from Phunchung village. For each land uses soil samples were collected from different reaches of the hillock (upper, middle and lower reaches). The soils were collected from two depths (0-15 cm and 30-45 cm) for each reaches. The soils were taken from 3 spots of each reach and depth, and finally collected soils were composited. The soil samples were air dried, crushed and grounded to pass through a 2 mm sieve and then analyzed for different chemical properties of the soil. Standard procedures were followed to estimate all the soil fertility parameters. The collected data were analyzed and calculated by using Randomized Block Design (RBD).

3. RESULTS AND DISCUSSION

Data on available N, P_2O_5 and K_2O in the soil at different depths as affected by different land use system are presented in Table 1 and Table 2 and it was observed that forest area showed significantly the highest available N (533.49 Kg/ha and 475.14 Kg/ha) in both the soil depths i.e. 0-15 cm and 30-45 cm respectively followed by Jhum cultivation after 15 years of Chandel district (512.54 kg/ha in 0-15 cm and 468.49 kg/ha in 30-45 cm soil depth). This could be as a result of natural farming's increased deposition of dead organic materials, plant litter, and nitrogen-fixing microorganisms as reported by Lobe et al. [10].

Similarly, in the case of available P_2O_5 in the soil as affected by different land use system was observed highest in forest areas (10.92 kg/ha) in 0-15 cm depth and 9.97 kg/ha in 30-45 cm soil depth followed by Jhum cultivation after 15 years of Chandel district (10.22 kg/ha) in 0-15 cm soil and 9.07 kg/ha in 30-45 cm soil depth. The findings are in close conformity with the finding of Kewat et at. [11]. The land use types have significant effect on soil nutrients and thus its fertility, Petevino Chase and O. P. Singh., [12]. The lowest available P_2O_5 in the soil was recorded from pine forest with 5.19 Kg/ha and 3.94 kg/ha P_2O_5 in 0-15 cm and 30-45 cm soil depth respectively. Increased leaf litter may contribute to higher available N and P_2O_5, as it acts as mulch and prevents the loss of macro and micronutrients that are critical for plant growth [13].

Also available K_2O as influenced by different land use system was observed highest in forest soil in both the soil depth i.e. 278.08 kg/ha and 266.11 kg/ha respectively and lowest was recorded from pine forest in both the soil depth. The primary reason for higher available soil nutrients could be

Table 1. Available N and P_2O_5 present in soils of different land use system

Different land use system	N (Kg/ha)		P_2O_5 (Kg/ha)	
	0-15 cm	30-45 cm	0-15 cm	30-45 cm
Forest areas	533.49	475.14	10.92	9.97
Jhum cultivation after 15 yrs	512.54	468.49	10.22	9.07
Jhum cultivation after 10 yrs	486.62	454.24	9.55	8.42
Jhum cultivation at 10 yrs from different sub division of the district	461.56	439.30	9.15	8.20
Jhum cultivation after 5 yrs	427.01	408.88	8.24	7.13
Intermittent jhum areas	410.56	396.95	7.58	6.16
Oak forest	373.08	348.32	6.10	5.10
Teak forest	345.73	327.83	5.98	4.70
Pine forest	277.31	253.16	5.19	3.94
Agri-horti jhum cropping system	379.27	363.43	6.39	5.50
Maize based cropping system	296.03	275.37	5.44	4.11
C.D.	**34.27**	**8.70**	**0.60**	**0.80**

Table 2. Available $K_2O$and OC (%) present in soils of different land use system

Different soil samples of Jhum land	K_2O (Kg/ha)		OC (%)	
	0-15 cm	30-45 cm	0-15 cm	30-45 cm
Forest areas	278.08	266.11	2.73	2.04
Jhum cultivation after 15 yrs	264.33	253.59	2.42	1.86
Jhum cultivation after 10 yrs	250.56	242.66	1.86	1.35
Jhum cultivation at 10 yrs from different sub division of the district	241.84	232.00	1.69	1.09
Jhum cultivation after 5 yrs	210.14	201.90	1.38	1.03
Intermittent jhum areas	186.88	176.71	1.26	0.95
Oak forest	128.58	120.41	0.96	0.73
Teak forest	126.83	114.22	0.85	0.60
Pine forest	106.98	94.27	0.54	0.34
Agri-horti jhum cropping system	144.00	133.31	1.05	0.76
Maize based cropping system	113.16	101.01	0.75	0.48
C.D.	**2.13**	**2.92**	**0.19**	**0.24**

due to higher tree density and litter inputs in the forest which shows positive impact on the soil nutrient content in the forest. The findings were in close conformity with the findings of Kharal et al. [14].

Organic carbon in the soil due to different land use system was found to be significant in both the soil depth in all the different land use systems. Significantly the highest organic carbon content was recorded in forest soils in both the soil depths of 0-15 cm and 30-45 cm sowing the data of 2.73 and 2.04 % respectively followed by Jhum cultivation after 10 years at Lamphoucharu area of Chandel district (2.42%) in 0-15 cm soil and 1.86 % in 30-45 cm soil depth. The least organic carbon content in both the soil depths of 0-15 cm and 30-45 cm was 0.54 % and 0.34% respectively was observed from pine forest of Chandel. The high organic carbon content in the forestland could be as a result of tree leaves, stems, barks, ˆflowers, logs, and fruits. In addition, microorganisms, animals, and roots contribute to the increased of organic carbon. The findings are similar with the findings of Nanganoa, et al. [15].

4. CONCLUSIONS

Land use change influences a number of biological and physiological processes of the soil. Poor soil health and land degradation can result from poor land use decisions. Based on the study area of different land use system, it was found that areas with less disturbed have significant amount of higher soil nutrients and soil organic carbon in both the different soil depths. Soils of Chandel district are varied in soil fertility status. The soils collected from different land use systems of Chandel district are high in organic carbon content, however amelioration of soil acidity and external inputs of essential nutrients is necessary for successful crop production. According to soil nutrient based study in different land use systems, we found that the soil fertility is deteriorating in more disturbed areas with less vegetation cover. So careful consideration should be given to land use decisions in order to maintain the quality of the soil and also to enhance higher crop production and productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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