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Analysis of Carbon and Nutrient Storage of Soil in Various Land Use Systems in Madhya Pradesh

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Abstract

The current study was focused on the analysis of carbon and nutrient storage of soil in various land use systems in Amarkantak region**.** The study was conducted during 2016**-**2017 and during the study the soil sample was collected from different land use system **(**i.e**.** Forest ecosystem, Grassland, Agriculture land and Pine plantation**)** at the depth of 0**-**20 cm and 20**-**40 cm with the help of soil auger**.**The status of pH ranged from 6.10 to 7.13 at 0-20 cm depth and it was recorded 6.12 to 6.98 at 20-40 cm depth, from all the different land use systems and the pH of Agriculture field was recorded maximum 7.13 at the depth of 0-20 cm, followed by Agroforestry field 6.39 at 0-20 cm depth, Grassland 6.38 at 20-40 cm and lowest was recorded 6.10 at the depth of 0-20 cm in Pine plantation. EC values ranged from 66.1µs to 349 µs in four different land uses. Maximum EC 349µs at 0-20 cm was observed in Agricultural field, followed by 337 µs in Agroforestry field at 0-20 cm depth, Grassland was recorded 214µs and minimum were found 66.1 µs in Pine plantation. The Total Dissolving Salt (TDS) and salt concentration ranged between 70.3 ppm to 271 ppm and 38.3 ppm to 271 ppm at 0-20 cm and 20-40 cm in all the different field systems, respectively.

The highest quantities of Nitrogen were observed in Agroforestry system 405 kg ha^{-1} at the depth of 0-20 cm and phosphorus was observed in Agroforestry system and Agricultural system same value 25 kg ha^{-1} at the depth of 0-20 cm and 20-40 cm. The highest potassium was observed in Agroforestry system that is 280 kg ha^{-1} at the depth of 0-20 cm. The status of Nitrogen, Phosphorus and potassium show mixed trends regarding the cultivation practices and depth of soil in case of agroforestry system, agriculture system and pine plantation but in case of grassland system it was shows a significant difference with another systems.The highest soil organic carbon and soil organic matter was recorded maximum in pine plantation that is 2**.**17 **%** and 3**.**74 **%**, respectively at the depth of 0**-**20 cm followed by 1**.**72 **%** and 2**.**96 **%** in Grassland system at the depth of 20**-**40 cm, 1**.**8**%** and 3**.**09**%** in Agricultural system at the depth of 0**-**20 cm, respectively**.**

Keywords: Carbon Storage, Pine Plantation, Nutrient Stock, Agroforestry, Grassland.

Introduction

The role of land use in stabilizing CO_2 levels and increasing carbon sink potentials of soils have attracted considerable scientific attention in the recent years (Arnhold*et al.*, 2015; Fu *et at.*, 2010). Specifically, it has been well demonstrated that the SOC stock of ecosystem was significantly affected by the land use/cover change especially to agriculture activities (Wu et al., 2003; Gelaw et al., 2014). Deforestation (Fujisaki et al., 2015), afforestation (Barcena et al., 2014). As a summary, most of these studies have largely focused on SOC Variability under different land uses and soil depth in horizon and vertical layers. The SOC stocks of forest lands were higher than that in cropland in humid tropics or drought loess region (Fujisaki *et al.,* 2015; Zhang *et al.,* 2013). However, there is still great uncertainty in semi-humid hilly area.

Soil is the largest terrestrial pool of organic carbon (IPCC, 2007). Slightly changes in the soil organic carbon stock (SOC) could cause. Signification impacts on the atmospheric Carbon concentration (Davidson and Janssens, 2006). SOC pool may greatly change responses to a host of potential environmental and anthropogenic driving factors. Besides, SOC and total nitrogen (STN) can provide nutrients for plant growth and maintain good soil physical structure. Therefore, the research of SOC and STN concentration and stock is essential in increasing crop productivity and alleviating carbon emissions. Therefore, a study of this nature was undertaken withthe following aims and objectives;

1. To determine the physical properties of soil indifferent land use practices
2. To evaluate the nutrient storage(N, P & K)in soil in different land use systems
3. To study the Soil organic carbon (SOC)and Soil organic matter(SOM)in various land uses**.**

Materials and Methods

The present study revealed on**"**Analysis of carbon and nutrient storage of soil in various land use systems in Madhya Pradesh**"**in the Amarkantak region of Madhya Pradesh and the analytical work has been carried out in the Soil and Plants Analysis Laboratory of Department of Environmental Science, Indira Gandhi National Tribal University, Amarkantak, Anuppur district of Madhya Pradesh, India during 2016-17.

Study Area

The study area was representing a dry tropical ecosystem in Amarkantak region, was selected for the analysis of Carbon and nutrient (N, P & K) storage in soil in different land use systems (i.e. Agriculture, Agroforestry, Pine plantation and Grassland).The mean temperature in January is about 21ºC and in May temperature rises between 31ºC and 33ºC. The mean annual temperature ranges between 21ºC and 31ºC. The annual rainfall of the area is about 1624.3 mm distributed over an average annual rainy day of 92 (range 71-118 days). The altitude varies from 450 to 1102.27 m above msl with the highest point being Damgarh(1,102.27 m). The soils of the area are generally lateritic, alluvial and black cotton types, derived from granite, gneisses and basalts. Due to varied climatic, topographic and edaphic conditions, the reserve harbours the unique diversity flora and fauna. The vegetation of the forest area of the reserve represents tropical deciduous and can be further classified into Northern Tropical Moist Deciduous, Southern Dry Mixed Deciduous forests, scrub and thorn forests and ravenous vegetation.

Nutrient Analysis of Soil of Four Different Land Use Systems

Physical Properties

The physical properties of soil in various land use systems were determined with the help of given mentioned below formulas and study revealed that the physical parameters i.e. pH, EC and TDS were measured in collected samples from the different four land use systems.

Soil Sampling

The soil samples were randomly collected from the studied quadrates of different land use systems (*i.e.* Agriculture, Agroforestry systems, Grassland and Pine plantations) at soil depth of 0-20 cm and 20-40 cm with the help of soil auger. Soil samples were thoroughly mixed and a composite sample was ready for the analysis. The total 40 soil samples (4 sample points x 5 quadrates x 2 depths) were collected and dried in shade and subjected to physico-chemical analysisof given soil samples.

Nutrient Analysis

Nitrogen analysis of the collected soil samples were chemically determined by Micro-Kjeldahl method (Jackson, 1967) by digesting methods and followed by distillation and titration. The total phosphorous was determined by using spectrophotometer (Olsen*et al.,* 1954)and thePotassium was determined by flam-photometer method (Jackson, 1967). The organic carbon in soil was determined following Walkley and Black method (1934).The amounts of nutrients and C in soil were determined by multiplying soil volume, bulk density and respective concentrations of C and nutrient values for given soil depth corresponding to all land use systems. These values converted into kg ha^{-1}.The determination of soil organic matter and soil organic carbon in various land use systems has carried out.

Statistical Analysis

The significant difference between treatment means for all physical and chemical parameters of soil in different land use (i.e. Agriculture, Agroforestry, Grassland and Pine plantations) were tested at $P < 0.05$ using least significant difference test (Gomez and Gomez 1984).

Results

Determining the Physical Properties of Soil in Four Different Field Practices

The present study was intensive on the analysis of soil properties of different land use practicessuch as agroforestry, agriculture, grassland and pine plantation. The study was conducted during the study the soil sample was collected from different land use system at the depth of 0-20 cm and 20-40 cm with the help of soil auger. The analysis of soil was carried out in the laboratory of Department of Environmental Science at Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh. The outputs of current study are physiochemical properties of different field system's, status of Nitrogen, Phosphorus, Potassium, and organic carbon and organic material status in the soil of different fields. The physical characteristics of the soil on different field practices are depicted in Table 1. The physical properties of soil viz; pH, EC, TDS and salt concentration show a significant resultamong all four land use practices.

Table 1: Physical Properties of Soil in Four Different Field System

S.No.	Land use	pH		EC(µs)		TDS (ppm)		Salt concentration(ppm)	
		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	Agroforestry	6.39	6.12	337	335	271	241	195	161
2.	Agriculture	7.13	6.98	349	320	241	221	158	153
3.	Grassland	6.15	6.38	175.5	214	126	145	87.5	102
4.	Pine plantation	6.10	6.28	99.0	66.1	70.3	46.9	52.5	38.3

The status of pH ranged from 6.10 to 7.13 at 0-20 cm depth and it was recorded 6.12 to 6.98 at 20-40 cm depth, from all the different land use systems which are depicted in table 1. Result shows that the pH of different field was significance among all the land use practices. The pH of Agriculture field was recorded maximum 7.13 at the depth of 0-20 cm, followed by Agroforestry field 6.39 at 0-20 cm depth, Grassland 6.38 at 20-40 cm and lowest was recorded 6.10 at the depth of 0-20 cm in Pine plantation. The trends of pH in different field system shows that the approximately neutral in nature which reflect the suitability of field condition for almost all crops.

EC values ranged from 66.1µs to 349 µs in four different land uses. Maximum EC 349µs at 0-20 cm was observed in Agricultural field, followed by 337 µs in Agroforestry field at 0-20 cm depth, Grassland was recorded 214µs and minimum were found 66.1 µs in Pine plantation (Table 1).The Total Dissolving Salt (TDS) concentration ranged between 70.3 ppm to 271 ppm at 0-20 cm and 46.9 ppm to 241 ppm at 20-40 cm in all the different field systems, being higher in agroforestry system 271 ppm at the depth of 0-20 cm and lowest was recorded in Pine plantation 46.9 ppm at the depth of 20-40 cm (Table 1).The salt concentration ranged from 38.3 ppm to 195 ppm. The salt concentration values were recorded highest in 195 ppm at the depth of 0-20 cm and lowest was recorded in Pine plantation 38.3 ppm at the depth of 20-40 cm.

Nutrient Status (NPK) of Soil under Different Land Use Practices

N, P, and K are the key element for growth and development of plant. The status of these element varied in soil according to cultivation practices, climatic condition, depth of soil and locality of site. In the current study we observed the varying pattern of NPK in the soil. Present study indicated that the depth of soil and cultivation practices are varied which result the varying pattern of N, P, and K. The nutrient status of these four systems are evaluated.The total nitrogen content varied from 189-405 kg ha^{-1} at 0-20 cm depth and 287-315 kg ha^{-1} at 20-40 cm depth in all four different fields. The maximum nitrogen content in soil was recorded in Agroforestry system 405 kg ha^{-1} at the depth of 0-20 cm, followed by Pine plantation 400 kg ha^{-1} at the depth of 0-20 cm, Agricultural system was found 320kg ha^{-1} at the depth of 0-20 cm and minimum were recorded 189 kg ha^{-1}in grassland field. The data of total nitrogen content in soil are depicted in Table 2.The total phosphorus content in soil ranged from 7.5 – 25 kg ha^{-1} at 0-20 cm depth and it was observed 5.00 – 25 kg ha^{-1} at 20-40 cm depth, from all land use systems. The maximum phosphorus content in soil were recorded 25 kg ha^{-1} in Agroforestry system and Agricultural system at 0-20 cm depth and 20-40 cm depth, respectively. The minimum 7.5 kg ha^{-1} and 5.00 kg ha^{-1} in grassland system of 0-20 cm and 20-40 cm depth of soil, respectively.The status of potassium content ranged from 120 -280 kg ha^{-1} at 0-20 cm depth and it was observed 117 -255 kg ha^{-1} ranged at 20-40 cm depth from all the systems. The potassium content was recorded maximum values 280 kg ha^{-1} Agroforestry system at 0-20 cm soil depth and minimum 117 kg ha^{-1} was found in Grassland system at 20-40 cm soil depth.

The status of Nitrogen, Phosphorus and potassium show mixed trends regarding the cultivation practices and depth of soil in case of agroforestry system, agriculture system and pine plantation but in case of grassland system it was shows a significant difference with another system.

Table 2: NPK Quantities of Soil in Four Different Field Practices (kg ha^{-1})

S.N	Site	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	Agroforestry	405	306	25	6.2	280	255
2.	Agriculture	320	309	15.7	25	187	160
3.	Grassland	189	315	7.5	5.00	125	117
4.	Pine plantation	400	287	13.5	11.2	120	233

Determination of Soil Organic Carbon (SOC) and Soil Organic Matter (SOM) in Different Field Systems

Carbon acts as a building block for plant and soil in the nature**.** The quantity of carbon in soil represents the availability of organic matter in soil**.** The organic matter is a source of essential nutrient for plant in soil**.** It also facilitates the activity of beneficial microbes in soil**.** The carbon content of soil varied according the vegetation and climatic condition of particular area. The natural forest has richest source of carbon compare to other cultivation practices, however the agroforestry field also have considerable amount of carbon compare to sole agricultural field. The soil organic carbon and soil organic matter status of these four systems are evaluated.As shown in table 3 the highest soil organic carbon and soil organic matter was recordedmaximum in pine plantation that is 2.17 %and 3.74 %, respectively at the depth of 0-20 cm followed by 1.72 %and 2.96 %in Grassland system at the depth of 20-40 cm, 1.8%and 3.09%in Agricultural system at the depth of 0-20 cm, respectively. While, minimum concentration was recorded in agroforestry system that is 1.8%and 2.32%at the depth of 0-20 cm and 20-40 cm.

Table 3: Soil Organic Carbon (SOC) and Soil Organic Matter (SOM) of Soil in Fourdifferent Land Use Practices

S.N.	Site	Soil organic carbon in (%)		Soil organic matter in (%)	
		0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	Agroforestry	1.8	1.35	3.09	2.32
2.	Agriculture	1.8	1.5	3.09	2.58
3.	Grassland	1.65	1.72	2.83	2.96
4.	Pine Plantation	2.17	2.1	3.74	3.61

The above data of nutrients revealed that the Agroforestry and Agricultural systems were superior in case of soil properties compare to other field systems and the soil depth 0-20 cm are found superior or nutrient rich in all type of field systems.

Discussions

The physiochemical properties of four different field such as Agroforestry, Agriculture, Grassland and pine plantation. The most favourable physiochemical properties of soil are found in agroforestry followed by agriculture, pine plantation and grassland. In the agroforestry field, tree component incorporated are belong to Leguminosae family. The NPK are the macro nutrient also called primary nutrients, required in large amount viz; more than 1 ppm. The agroforestry practices have significant beneficial compare to monoculture in improvement of soil fertility by adding nutrient in soil through tree component incorporated with it. The agroforestry practices have closed type of nutrient cycle which result more addition of nutrient compare to lossand very interestingly, several workers reported significantly results in agroforestry systems in India and abroad (Nair 1984; Pandey 2007; Bijalwan*et al*. 2017; Kumar and Thakur 2017 and Verma *et al*. 2017).In our study the highest quantity of nitrogen and phosphorus in soil is observed in soil is observed in agroforestry system at the depth of 0-20 cm while potassium content is higher in agroforestry system at the depth of 0-20 cm and similar study were done by Pandey *et al.*(2000), he revealedsoil properties under Acacia nilotica trees in a traditional agroforestry system in central India.The grassland system found lowest trend regarding the NPK status of soil. The present studies revealed that leguminous component in field add nitrogen by fixing of soil nitrogen. While, other nutrients like phosphorus add through mycorrhizal association of tree component in the field. In case of pine plantation, the presence of high carbon content results the highquantity of nitrogen and phosphorus. However, pine plantation soil is poor in nutrient compare to agroforestry practices.Carbon is the basic element for plant growth the organic matter content of soil depends on the availability of carbon in soil. Soil organic carbon and soil organic matter are very important parameter of soil as they improve soil structure, its drainage and aeration, water holding capacity, buffer and exchange capacity. soil organic carbon also important in controlling the available nitrogen in soil. During the present study we compare the soil organic carbon and organic matter in four different field practices and found the highest carbon and organic matter in the pine plantation at the depth of 0-20 cm. The surface soil has rich in organic carbon and organic matter due to the crop residues and plant detritus matter. The legume component add more organic carbon that result high content of organic matter. The organic matters in the field add 95% Nitrogen and 33% phosphorus in soil.As we know the fertility of soil are important parameter for production/ productivity of any crop and plant. Soil fertility is the capacity of soil to produce crops of economic value and to maintain health of the soil without deteriorationand various researchers worked on similar theme (Dhiyani*et al*. 2013; Singh and Gill 2014). During the present study it is observed that Agroforestry field is high fertile due to best physiochemical properties, high NPK and high organic matter content in pine plantation followed by agroforestry system, agricultural system and grassland system. At same time, it is also observed that surface soil (0-20) is highly nutrient rich and preferable for cultivation of crops. The present study recommended that incorporation of at least one component belonging to leguminous family in agroforestry practices are highly preferable and beneficial which show better result regarding the health and fertility status of soil.

Conclusions

Compared with cropland, Agroforestry, Agricultural and land different ages of forestlands resulted in greater amounts of SOC and STN. SOC increased with the age of forestland generally, while STN had better enrichment and humus when understory well growth with biodiversity and biomass in young forestland. SOC and STN concentrations and stocks generally decreased with increase in depth of land uses. Given that 40.7% of SOC stocks in cropland and 43.6% in shrub land are concentrated in the top 20 cm of surface soil. there is a risk of large amount of carbon loss following soil plough in human disturbance. Thus, rational agriculture cultivation is important to increase the potential of carbon sequestration.Generally, the result of this study can be concluded that land use change from cropland to secondary shrub and forest plantation improved SOC and STN concentrations and tocks. Therefore, adoption of restoration in land uses, conversion of cropland to shrub land or forestland, has large potential for SOC and STN sequestration in the region.

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