Assessment of Soil Physicochemical Properties and Soil Organic Carbon Pool under Different Land use Systems in Chhindwara District of Madhya Pradesh

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CERTIFICATE

To,
The **Registrar**
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Dear Sir,

We have great pleasure in the forwarding of the thesis entitled **"Assessment of soil physicochemical properties and soil organic carbon pool under different land use systems in Chhindwara district of Madhya Pradesh"** submitted by **Mr. Udit Pahade,** I.D no. 20430SAC034 in partial fulfilment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Soil Science - Soil and Water Conservation,** Institute of Agricultural Sciences, Banaras Hindu University, Rajiv Gandhi South Campus, Barkachha, Mirzapur.

It is certified that the entire scheme of investigation reported herein, was planned and carried out by the candidate under my guidance, to the best of my knowledge and belief; the data presented in the thesis are genuine and original. No part of the work has been submitted for any degree or distinction.

Yours faithfully,

(Dr. A.M. Latare)

Head ***Course Coordinator*** ***Supervisor***

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Date: **Udit Pahade**

Place: Varanasi

LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Per cent
Agri.	-	Agriculture
BD	-	Bulk density
DTPA	-	Diethylenetriaminepentaacetic acid
EDTA	-	Ethelene di amine tetra acetic acid
cm.	-	Centimeter
Dept.	-	Department
dSm^{-1}	-	Desi simen per meter
EC	-	Electrical conductivity
et al.	-	*Et alia,* and others
Fig.	-	Figure
$g\ kg^{-1}$	-	Gram per kilogram
ha.	-	Hectare
i.e.	-	*Id est,* that is
J	-	Journal
K	-	Potassium
$kg\ ha^{-1}$	-	Kilogram per hectare
Max.	-	Maximum
$mg\ kg^{-1}$	-	Milligram per kilogram
Mha	-	Million hectares
Min.	-	Minimum
mm.	-	Millimeter
N	-	Nitrogen
No.	-	number (s)
O.C	-	Organic carbon
^oC	-	degree Celsius
P	-	Phosphorus
pH	-	Puissance de hydrogen
PD	-	Particle density
S	-	Sulphur
S.N	-	Serial number
Sci.	-	Science
Soc.	-	Society
sq. km	-	Square kilometer
Univ.	-	University
Temp.	-	Temperature
viz.,	-	Vide licet, namely
WHC	-	Water holding capacity

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Chapter-I

Introduction

The term "soil" comes from the Latin word "solum," which means clay where the plant grows." The science branch is known as pedology or edaphology. It is critical to research soil in addition to plants. Soil is a three-layered regular body of the scene shaped by the enduring of rocks through different pedogenic processes, comprising of natural and inorganic matter components accessing a specific variety of mechanical, substance, and natural qualities with a changeable composition deeper, which includes the earth's texture and provides a medium for terrestrial plant life.

Soil is a natural habitat for both plants and animals. Humans first discovered minerals and nutrients in the soil. Agriculture benefits greatly from soil research. Soils anchor plant roots to the ground and provide physical stability. Soil provides humanity's most fundamental requirements. It is beneficial to our farming operations. Agriculture, among other things, plays a significant role in economic growth through the cultivation of crops, fruit, vegetables, and fruits. This is accomplished due to the soil's physicochemical properties and it is critical for the successful execution of the other management strategies. The physical and chemical qualities of the soils are used to assess all agricultural products and forest growth.

Soil is composed of different types of combinations of minerals, organic compounds, liquids, and oxygen. The consistency, arrangement, and permeability of the soil are all impacted by these components. These attributes accordingly influence air water course in layers of Soil, lowering the condition of the land to perform. As a result, physical and chemical characteristics in the soil have a big influence on soil consistency. The texture of the soil, in particular, may have a significant impact on many other qualities. As a logical consequence, the texture of soil is one of the most important physical features.

The texture of soil, in actuality, is a compound categorised into three constituent elements: sands, clay, & silt. The fine mineral fraction is made up of these particles, which vary in size. The coarse mineral fraction, which comprises particles larger than 2 mm in diameter, is often not considered in texture. However, in some situations, they may have an impact on soil physicochemical qualities such as water retention. The relative number of various particle sizes in a soil determines its textural category, that is, whether it is clay, loam, sandy loam, or another.

Corn City is another name for Chhindwara. Maize is produced across the area due to the availability of adequate soil and the environment required for corn cultivation. The grain produced is also exported to neighbouring areas. Oranges are one of the most popular summer fruits. Oranges are farmed in the Sausar and Pandhurna areas of Chhindwara, close to the Maharashtra border. Oranges from these two districts are sent to Nagpur, often known as the "Orange City."

In the southwest portion of the Satpura mountainous area, the Chhindwara district is situated. The district is situated between North Latitudes 210 'and 220 'and East Longitudes 780 'and 790 'on the state's southern border, covering an area of 11,850 square kilometres. A total of 12 tahsils make up the district (Chhindwara, Parasia, Harrai, Umreth, Pandhurna, Chourai, Tamia, Mohkhed, Bichhua, Amarwara, Sausar, Jamai). The River Narmada and River Godavari, as well as the river Wain ganga reborn, are all within the district's boundaries. The Narmada River and River Wainganga have respective catchment areas of 3555 and 8295 square kilometres in the district. The Godavari River has tributaries such as Kanhan, Pench, and Wardha, whereas the Narmada River has tributaries such as Sakkar, Dudh, and Sitarewa.

There are three types of soil in the district: black cotton soil, sandy loam soil, and clayey loam soil. Sausar tahsil is known for its black cotton soils, whereas Chhindwara tahsil is known for its sandy loam soils. Clayey loam predominates in the Amarwara Tahsil. Loamy soils cover the northern hilly region, which is very superficial and shallow, overly depleted, has relatively steep hills, and suffers from severe deterioration. Soyabean, Tuar, Sugarcane, Urad, Cotton, Barley, Maize, Paddy, Urad, Peanuts, and wheat, chickpeas, and vegetables are the main crops. The overall irrigated area is 1504 square kilometres, with canals covering 108 square kilometres, tube wells covering 367 square kilometres, and open wells covering 928 square kilometres.

The four key pools of organic matter in soil are plant remnant, particles organic carbon, compost carbon, and refractory organic carbon. The chemical content, rate of decomposition, and importance of these pools in terms of soil performance and physical wellbeing vary. Not alone might management modify overall organic carbon stocks, but also the distribution of carbon within those different pools. Understanding whether carbon pool respond differently to operations can provide insight into soil growth and overall.

The proportion of each form of carbon contained in a soil may be used to evaluate soil health. The proportion of total carbon composed of plant matter and particle biodynamic carbon has the largest influence on a yearly delivery of fresh plant matter to such fields. Arrangements which produce a large amount of natural produce, including such properly maintained meadows or natural plants, contain a great deal of organic carbon residue and microscopic carbon material. Throughout agroecosystems distinguished by growth and yield, lengthy barren intervals, and working practises that accelerate the decomposition of organic matter (also including soil management and residue combusting), these carbon percentages are frequently low. Because labile carbon fractions are a source of energy of beneficial microorganisms, increasing number of microorganisms in such components may be a reliable indicator of a soil's biomass production. Although if multiple particles had same total soil organic carbon, a soil with 50 percent of the overall of its cumulative organic substances in the fragile pool indicates a somewhat more bioactive molecules soil with significantly larger nutrient profitability prospects but also improved soil composition besides a soil only with 5 percent of total among its total plant substances in fragile extracts. A soil with a higher fraction of total biomass in the resistant carbon pool, on the other hand, is likely to become less productive than one with the same total composition but a lower fraction of refractory plant biomass.

Soil carbon is significant because it influences soil fertility, water-holding capacity, and other soil properties, hence determining ecosystem and agro-ecosystem functions. It is also of worldwide significance due to its position in the global carbon cycle and, as a result, the role it plays in mitigating atmospheric levels of greenhouse gases (GHGs), particularly C*O 2 due to global warming (Bhattacharyya *et al.* 2008a). Authors have attempted to estimate global soil organic carbon reserves, with varied degrees of success (SO) (2006). Batjes (1996) revised previous estimates and emphasised the role of the tropics in global soil carbon storage. Soil enrichment with organic carbon has also been proposed to reduce global warming and assure global food security (Lal * 2004).

The carbon inside the soils that is biological is known as soil organic carbon that remains after the partial degradation of any substance created by living organisms. This is a critical part of soil organic carbon and is known to have antimicrobial properties be important for many soil processes and ecological features. The amount of organic carbon in a soil is determined by geology, climate conditions, land use, and management. The top soil has the most organic carbon (2500 pg. of c to 2-m depth). Because there is twice as much carbon in soils as there is in the environment, soil serves as a significant carbon storage.

Chapter-II

Review of Literature

The aim of this study was to investigate the "Soil Organic Carbon Pools under different land use systems and Physico-chemical Properties in Chhindwara District Madhya Pradesh". Soil samples were collected from different depth from various land use systems and analyzed for physio-chemical, available nutrient contents and soil organic carbon pools.

The literature pertaining to the study entitled "Assessment of soil physicochemical properties and soil organic carbon pool under different land use systems in Chhindwara district of Madhya Pradesh" had been reviewed under the following heads.

2.1 Soil Organic Carbon Pools under different land use condition

2.2 Soil Physico-chemical Properties under different land use conditions

2.1 Soil Organic Carbon Pools under different land use condition

Chan *et al.* (2001) variations in POC comparative to TOC in soils having diverse variety of terrestrial use and maintenance techniques. Particulate Organic Carbon accounted for 41 to 75 percent of total organic carbon and was higher grazing and less intensive management than traditional farming systems. Whenever long-term grazing soil were converted to farming, this was the kind of organic carbon that was disproportionately destroyed. That was also the most prevalent type of organic carbon that collected as a result of more conservative management (direct drilling, stubble retained and organic farming). POC variations contributed for 84 percent (range 69 to 94 percent) of TOC changes across all sites, owing to differences in land use and management.

Ramachandran *et al.* (2007) assessed the carbon stock in a characteristic backwoods area of Kolli slopes, part of the Eastern Ghats of Tamil Nadu, India utilizing geospatial innovation. The complete biomass, both above and subterranean, is determined and the absolute carbon stock assessed. Moreover, the sequestered soil natural carbon is additionally assessed. The biomass carbon assessed is 2.74 Tg and the soil carbon is 3.48 Tg. The lesser soil natural carbon shows that the timberland region is seriously impacted by debasement because of different need-based ranger service rehearses and anthropogenic unsettling influences.

Negi *et al.* (2010) assessed the soils carbon sequestration storage in the Giri watershed, and it was revealed that the soil under Kail & Silver fir, Pine timberlands and Kailwoods had the highest SOC store (94.47 t ha), following the Deodar forests (83.14 t ha'). Soil carbon store was equivalent in unexpected natural forests (58.67 t ha') & deodar backwoods (57.35 t/ha), with Sal forests (48.39 t/ha) having the lowest. Trimming framework organic soil store was 54.61 t/ha in farmland, while it was 54.96 t ha' in plantations. Soils above 2500m (91.37 t/ha) had some of the most extensive organic soil carbon storage, followed by soils between 2000m & 2500m. (89.68 t ha"). The soil with the lowest SOC store (53.34 t ha') was identified beneath 1000 m. The forest section of the Giri watershed has a soil natural carbon store of (8.26 million tonnes), while the horticultural lands use soil natural carbon storage is (3.17 million tons).

Wani *et al.* (2010) calculated total soil carbon density and stock using soil organic carbon (0–30 cm) point data for 05 AESR. The research area's total crop and soil C stocks were 34.94 and 790.61 Tg, respectively. The greatest crop biomass carbon was found in the Narmada River as well as the Malwa Plains under hot, dry, and humid conditions in AESR III. Satpura range and Wainganga River with hot moist sub-humid conditions (AESR V) reflected the lowest carbon from plant biomass (14.12 Tg), whereas Warm, damp, and sub-humid climate in the Satpura Mountains and Wainganga Valley conditions reflected the highest Carbon in crop biomass (14.12 Tg). (2.71 Tg). Crop biomass C concentrations were highest (3.95Mg C/ha) and lowest (0.50 Mg C ha^{-1}) in the Indore & Shahdol areas, respectively. Soil Organic Carbon stores ranged to 263.23 Tg from 74.7 Tg (AESR V) (AESR VI) (AESR 3).

Gupta *et al.* (2011) reported that the highest SOC pool was in forest lands, followed by grasslands, orchards and plantation sectors. In this location, the woods had a soil organic carbon pool of 15.84 M ton (78.49 t ha^{-1}) & P. smithiana and a Since pindrow forests can store more than twice as much SOC than S. robusta, they have greater potential for mitigation. There were 1.40 million tonnes of SOC pool in the environment and environmental orchards, accounting for 13.05% of the total carbon's pools of Uttarakhand's orchards. P. malus showed a mitigation potential of 2.71, indicating that it can have a soil organic carbon pool that is more than double that of P. guava. In the grasslands, the SOC Pool was 75.76 t/ha. Forest lands had highest SOC pool. Differences in SOC pool under various land uses were significant statistically (p 0.05). The average SOC content in woods was 78.49 t ha^{-1}, orchards 54.33 t ha^{-1}, plantations 46.13 t ha^{-1} and grasslands 75.76 t ha^{-1}. Among the forest species, P. smithiana and A. pindrow forests had the greatest capacity to store SOC, but P. malus had the greatest potential to stores SOC in fruit crops. In tree plantations, the capacity to accumulate SOC was 1.3 times greater in Eucalyptus spp. than in D. sissoo.

Panwar *et al.* (2013) A review was led to gauge the natural carbon pools in the soil in various woodland type in Himachal Pradesh. SOC pools was likewise assessed all woods available sub-bunch types in H.P Most extreme pool were in the soil below soggy Alpine Scrub (73.2 tons/ha) trailed Himalayan Moist Temperate Forests (55.2 tons ha^{-1}), Himalayan Dry Temperate Woods (47.6 tons/ha) & Sub-snowcapped Forests (45.67 tons/ha) and the least was under Tropical Dry Deciduous Forests (36 tons/ha). Damp Alpine Forests had greatest relief potential (2.03) also, the lowest was in Tropical Dry Deciduous Forests.

Ratan Lal *et al.* (2014) concluded that carbon dioxide (CO2) concentrations in the atmosphere are rising. Agroforestry systems are capable of contributing to lowering such increases and, consequently, to mitigating climate change. The term agroforestry relates to the agricultural, on the same piece of land, you can raise animals and grow trees for biomass. The only earthly lake that preserves much biomass is the pool of soil OC in soil. The areas of worldwide tree cropping system (700Mha), multiple states systems (100Mha), take necessary steps (300Mha), silvopasture (300 Mha) and tree woody biomass (450Mha) are expected.

Tariyal *et al.* (2014) estimated the carbon pool in 2 distinct system of vegetation, namely Bamboo plantations fields of agriculture. The biomass carbon store was determined to be quite considerable at both locations (C12 and D7) (5.28 & 5.12 t/ha). B. balcooa produced the most total biomass (479.13 t ha^{-1}) across all sites, and therefore biomass carbon stock was low (233.84 t ha^{-1}). In the case of bamboo, carbon sequestration capacity was shown to be higher in biomass than in soil, whereas in agricultural areas, its larger in soil than biomass. Thus, the current study clearly revealed that, in addition to its economic strength, bamboo plants have demonstrated promising outcomes in terms of carbon sequestration capacity. Furthermore, the study demonstrated the significance of agriculture in terms of potential Carbon Sequestration with the support effective cultivable practices.

Ghosh *et al.* (2015) reported that soils in Madhya Pradesh and Chhattisgarh were poor in accessible Phosphorus with organic c. In both areas, every field included that much K, while in Madhya Pradesh, the majority of fields contain just about the right amount of N and P. The availability of Phosphorus, Sulphur, Boron and Zinc components was strongly and substantially influenced by soil organic C in both phases.

Choudhary *et al.* (2016) studied the three key land use land cover arrangements in Tripura, and the impact of variable land use on SOC or other biotic and abiotic features. Jhum Fellow (121.88) had the highest absolute supply of Soil Organic Carbon (Mg Cha1), followed by Natural Forest (118.12) and Managed Plantation (85.36). Changes in topping profiles from Natural Forest to Managed Plantation and Natural Forest to Jhum Fellow culminated in a 37 percent and 11 points drop in SOC, correspondingly. Under this study, the critical variety in SOC stocks was discovered across diverse LULC.

Koppad *et al.* (2016) found that the SOC in soils of various land use classes is altogether unique. The aggregate and normal SOC in Haliyal taluka was 11.257 million tons (in 81792 ha) and 123.55 t/ha individually, likewise in Joida taluka was 20.69

million tone (in 177206 ha) and 83.59 t/ha, separately. Among the different land use Systems, in haliyal taluka thick timberland sequestered more SOC 184.08 t/ha, trailed by cultivation plantation (144.81 t/ha) where as in joida taluka thick woods sequestered SOC of 121.35 t/ha and open land (74.82 t/ha). It is inferred that deciduous timberland in Haliyal taluka sequestered more soil natural carbon contrasted with evergreen woods of Joida taluka because of more commitment from biomass in deciduous backwoods consequently woodland types assume a significant part in sequestering barometrical carbon in to the soil.

Pichhode *et al.* (2017) studied the carbon sequestration by several species of selected tree species in the Malanjkhand area forest in Madhya Pradesh's district Balaghat. Their research revealed 193 trees of 8 distinct species in one hectare of forest, including Mangifera indica, Azadirachta indica, Butea monosperma, Dalbergia sisso, Delonix regia and Madhuca indica, Tectona grandis, Eucalyptus citriodora, with a total carbon sequestered of 6.42 tonnes per hectare. Mangifera indica had the most total carbon sequestered at 2.014 t, while Eucalyptus citriodora had the lowest at 0.97 t.

Sahoo *et al.* (2019) estimated AC and PC pools through TOC in different land use patterns. Total Organic Carbon was maximum (2.75 %) in natural forest & minimum (1.31 %) in grassland, consequently, when the depth in various pools of lability increased, this decreased. Across different land use systems, a fraction of VLC ranged from 36.11 to 42.74 percent of TOC. Wet rice agriculture had the highest pool of AC (61.64%) while natural forests had the lowest pool of AC (58.71%).

Singh *et al.* (2021) analysed the effect of land use for the soil carbon stocks, soil microbial carbon, and abaxial gasp for air besides choosing a particular 16 land use patterns, one being cropland. When compared to alternative land use framework, the analysis indicate that the agroforestry framework performed better. In 0-15 cm soil depth, Acacia nilotica has the highest Soil Organic Carbon (24.38 Mg ha^{-1}), next by Dalbergia sissoo. In the 0-15 cm depth, Jatropha curcas had the highest Soil Organic Carbon (15.79 Mg ha^{-1}) among the unmodified tree ranching. However, silvopasture frameworks can generate more SOCs (20.89 Mg ha^{-1}) than conventional tree plantation frameworks. Soil Microbial Biomass Carbon was also significantly greater in 0-15 cm depth under Acacia nilotica (*765.61 lg g^{-1}), while substrate respiratory was most remarkable under silvopasture framework irrespective to Soil Organic Carbon and Microbial Biomass Carbon.

Das *et al.* (2021) surveyed the over-the-ground biomass, to study changes in soil organic carbon stocks, Active carbon, and passive Carbon pools. The outcomes uncover that AGC creation and Soil Organic Carbon stores went from 28.2 to 273.8 Mg ha^{-1}, as well as 97.3-109.2 Mg ha^{-1}. While absolute biological system carbon fluctuates between 132.3-438.4 Mg ha^{-1}. The amount of extremely labile carbon and labile carbon was considerably more prominent in elastic ranches matured 5 to 15 years. Less labile carbon and non-labile carbon levels were most noteworthy in 30 to 35 years. On account of the enormous measure of plant carbon, 35-year-old stands had the biggest biomass and soil natural carbon stores contrasted with more youthful stands.

Mourya *et al.* (2021) measured SOC fractions on 4 pedons in the Meghalaya plateau, India, with diverse landforms: denudational low hill, upper plateau, lower plateau, and valley. The results showed that the soils of the examined pedons were acidic, with limited cation exchange capacity and base saturation. Furthermore, the surface (0-30 cm) soils in the examined pedons had a high Walkley Black C concentration (0.83-1.13 percent). The density of very labile carbon percentage up to a depth of 150 cm was greatest (49.22 Mg ha^{-1}) in Pedon 2 in the higher plateau under shifting agriculture, whereas that of pedon 3 in the lower plateau was lowest. The greatest level of less labile carbon (LLC) (50.25 Mg ha^{-1}) was found in pedon 4 (P4) in the valley under rice agriculture. Higher concentrations of WBC and LLC in the valley (P4) compared to other landforms in the research region imply that valley soil has a higher carbon sequestration capacity. The soils of the examined pedons had high SOC concentration in the surface layer, were acidic in response, & had limited cation exchange capacity with low base saturation across the landforms, according to the results. Landform locations and land usage impacted different SOC fractions. Lower plateau and valley soils had greater concentrations of less labile carbon and WBC than denudational low hill and upper plateau soils, indicating that the soil organic carbon in the valley and lower plateau is more protective.

2.2 Soil Physico-chemical Properties under different land use conditions

Thakre *et al.* (2012) examined the samples of black and red soil from the Wardha region, it was discovered that black soil is alkaline in nature. The pH of red soil ranges from acidic to slightly alkaline. Black soil has a higher capability for cation exchange than red soil. The organic matter, accessible nitrogen, and phosphorus levels in red soils are low. The results indicate that red soil is less productive than black soil owing to low clay content, low water holding capacity, low organic matter, and poor nutritional status. The results also reveal that the various soil samples differ in many essential physical and chemical aspects. As a result, their ability to sustain diverse forms of land use is predicted to vary. As a result, the current investigation clearly demonstrated that changes in soil parameters.

Chaudhari *et al.* (2013) conducted the study on 7 soil samples which represent soils of that village of Yawal taluka, Jalgaon District. The results showed that all the soil parameters conductivity, pH, %Ca, % Mg, %N, %P, %K and % carbon is normal range. These studies give information about nature of soil, present nutrient in soil, according to this information farmer arrange the amount of which fertilizers and nutrients needed to soil for increase the percentage yield of crops.

Wani *et al.* (2014) collected sixteen soil samples from different Gwalior city areas (four agricultural, three highway, three industrial, three barren, and three market soils). In general, the agricultural soil samples were found to be more fertile than other areas investigated. However, when compared to industrial and barren soil samples, the fertility values of the industrial soil samples analysed in this study were moderate to medium. In the examined area, the variation in physicochemical qualities of the soils seemed to be impacted by topography to a higher extent. The study also concluded that industry and development projects are consuming Gwalior's agricultural land. The research also stated that industries and development projects are consuming the agricultural soil in Gwalior, posing a threat to agriculture's long-term growth and causing worry among farmers.

Singh *et al.* (2014) studied the fertility status of alluvial and medium black soils, ravenous land, and their correlation studies in Chambal region of Madhya Pradesh. Alluvial and medium black soils were neutral to alkaline, while ravenous land was neutral to alkaline. The soils were often deficient in soluble salts. Calcium carbonate with organic carbon content the range of available Nitrogen, Phosphorus, Potassium, and Sulphur was 127 to 362, correspondingly ravenous land Of alluvial soil samples, 97 percent were low and 3 percent medium in N; 14 percent were low, 68 percent medium, and 18 percent high in P; 1% were low, 35% medium, and 64% high in K; and 59 percent were low and 41% medium in S. 90 percent of medium black soil samples were low and 10% were medium in N; 21 percent were low, 69 percent medium, and 10% were high in P; 4 percent were low, 37 percent medium, and 59 percent high in K; and 51 percent were low and 49 percent medium in S. Organic carbon and silt plus clay content in soil were considerably and positively connected with available Nitrogen, Sulphur, Iron, Zinc, Potassium, Manganese, Molybdenum, Boron, whereas CaCO3 content in soil was substantially and negatively correlated with available Zn, Fe, Cu, Mn, B, and Mo.

Tagore *et al.* (2014) carried out research to investigate the geographical variability for essential fertilisers in a Malwa plateau soybean growing zone. The exponential model matches the observed semi-variograms of pH, EC, OC, available N, P, K, S, and Zn quite well. pH, EC, OC, N, and S and Zn showed minimal spatial dependency, but P and K showed significant spatial dependence. Cross validation of kriged maps demonstrates that employing semi-variogram parameters for spatial prediction of soil nutrients is superior to taking the mean of observed values for every un-sampled area. As a result, it is a good alternative approach for reliable assessment of chemical characteristics of soil in un-sampled sites to direct measurement, which has time and expense implications.

Sharma *et al.* (2015) suggested that the quality of the soil primarily determined by soil reaction to various land use regimes and management methods, which frequently alter soil characteristics & productivity of soil. Major Indicators of soil quality were studied in the Dimoria Tribal Belt of Assam under various land use schemes. Study's findings indicated that soil texture differed across all different land use systems. In numerous land use practices, soil moisture proportions vary between 17.2 percent to 25.31 percent, with bamboo plantations having the greatest proportion. The pH of the soil ranged from severely acidic to mildly acidic. 5.9 to 6.16 across different land use systems Organic Matter content in bamboo grooves greatest and lowest on teak plantation. When compared to other land use regimes, rice-cultivated land had more accessible potassium and nitrate nitrogen. While the available phosphorus in the natural forest was considerably greater.

Muche *et al.* (2015) evaluated the acidity status and physicochemical properties of soil in various land use types in the Alket Wonzi Watershed, Farta district, Northwest Ethiopia. Soil samples were collected at depths ranging from 0 to 25 cm on four different land use types: natural forest, cultivated land, plantation forest, and grazing land. Soils in the natural forest showed considerably higher soil pH (p0.05) and lower exchangeable acidity (p0.01). Likewise, considerably higher (p0.01) In comparison to other land use patterns, the soil of the natural forest had higher levels of exchangeable bases (Ca2+, Mg2+, K+), total nitrogen, organic matter, accessible potassium, cation exchange capacity, and clay content. The study also discovered a significant (p0.05) variation in accessible phosphorus among the various land use categories. However, there was no statistically significant variation in silt percentage, sand, bulk density, or exchangeable sodium amongst soils from different land uses. The study's findings revealed that grazing, cultivated, and plantation forest soils are all very acidic (pH 5.5).

Tewari *et al.* (2016) assessed the physico-chemical properties of soil from different terrain use systems viz. agriculture, olericulture in addition to two dominant woodland types (oak; Quercus leucotrichophora and pinus radiata; Pinus roxburghii) within Uttarakhand. The forest soil had considerably (p >0. 05) larger water holding capability, natural carbon, cation exchange capacity, accessible nitrogen and phosphorus and lower beliefs of pH, EC and available phosphorus as compared in order to the cultivated soil. Some of the particular physicochemical parameters this kind of as water having capacity, cation exchange capacity, available nitrogen and potassium had been found considerably larger for oak jungles compared to pinus radiata forests. The volume of natural CO_2, water holding capability and available potassium was higher regarding soils coming from olericulture fields in comparison with the particular agriculture field.

Dwivedi *et al.* (2016) studied the physico-chemical properties and heavy metals in soil of Rewa District. Fifteen soil samples were collected from three different area of Rewa District and values ranges of different parameters. The readings were taken with the help of Atomic Absorption Spectrophotometer (AAS). Iron and Zinc of all the soil samples were below the recommended level (Iron 380 mg/kg and Zinc 200 mg/kg) prescribed by SQGL value. The results confirm the sources of contamination to be anthropogenic from Industrial, urban and other anthropogenic activities in Rewa soil which has lead to the contamination of soil in the study area.

Shah *et al.* (2017) investigated the physico-chemical analysis for some parameters. Fifteen samples were taken and analyzed for its pH, EC, Phosphorus, Potassium, Sulfur and Carbon. It's observed that different areas of soil are influenced by the physicochemical properties of soils. Application of more labile organic inputs, liming materials and suitable inorganic fertilizers (N-P-K) would be effective for sustainable management and improving fertility status of the soils.

Parmar *et al.* (2017) assessed the chemical and physical properties of soils in different and use system Takoli Gad watershed, Uttarakhand. Samples were taken from 3 different depth [0-10] [10-20] and [20-30] cm. Different types of chemical and physical properties were taken and analysed and it is found the mostly acidic to neutral with pH value 6.4 to 7.3. The bulk density ranged from 1.13 gcm^3 to 1.95 gcm^{-3} in all land uses system and altitudinal zone. The moisture content is 2.68 % to 18.06 %. The higher moisture content was found in forest land (high altitude zone) and lower moisture content was found in forest, waste land (lower altitude zone) and the water holding capacity (WHC) varies from 28.71 % to 39.35 % in different land use system. The organic carbon ranged from 0.66 % to 1.17 % in all land uses and altitudinal zone.

Singh *et al.* (2017) assessed the fertility status of Mukundpur forest range located in the Satna district of Madhya Pradesh, India, in the Amar Patan Tahsil. The results show that soil pH does not alter considerably across all density groups. Electrical conductivity is essential in different density classes. The organic carbon content in the blank, encroachment, and stocked density classes is much greater than the average value. The observed value of available phosphorous in kg/ha maintains its average value of available phosphorous until density deterioration from stocked forest to blank forest occurs, however breaking of land in the incursion category improves the available phosphorus. The average value of accessible K_2O in blank, encroachment, and stocked classes does not differ substantially from the research area's typical K_2O value. The average value of Zn, Fe, Mn, and Cu in the incursion category varies greatly with the research area's average value. When we consider the combined influence of pH, electrical conductivity, and organic carbon on the research area, we find no significant relationship with respect to the varied densities of classes. Similarly, the combined influence of macronutrient (nitrogen, P_2O_5, K_2O) and micronutrient (Zn, Fe, Mn, and Cu) on study area does not show a significant connection with regard to various density classes.

Singh *et al.* (2017) studied the soil properties of Lahar block of Madhya Pradesh's Bhind District. The soils in the area have a moderate to high pH and a low to medium organic matter level. The soils had low to medium nitrogen levels, high phosphorus and potassium levels, medium to high sulphur levels, and adequate calcium and magnesium levels. Among the micronutrient soils, adequate iron, manganese, and zinc were found, but copper was insufficient.

Patidar *et al.* (2017) reported that the soils of Ralyawan village in Madhya Pradesh's Jhabua district were found to be low in accessible nitrogen, low to medium in available phosphorous, and medium to high in available potassium. The available nitrogen concentration in Ralyawan village soils averaged 237 kg per hectare & varied from 154 to 296 kg per hectare. In the soil of the settlement, the nutrient index values were in the low fertility class. This soil's available nitrogen status was observed to be complete. The available phosphorous status ranged from 8.23-39.2kg ha^{-1}, with a mean value 16.5 kg ha^{-1}. The research area's village soil samples are classed as low fertility 22.47 percent of the time and medium fertility 64.84 percent of the time. The nutrition index result for P was in the village's medium fertility class. The available potassium status ranged from 180-828 kg ha^{-1}, with a mean value of 421 kg ha^{-1}. The study's 0 percent village soil samples were classed as low fertility, 2.30 percent as medium, and 97.69 percent as high fertility.

Tirkey *et al.* (2017) assessed the soil nutrient level of soil in Korba area region Chhattisgarh from multiple perspectives, the pH value ranged from 6.03 to 7.41. The pH varied from 6.03 to 7.41, the EC ranged from 0.10-0.37 dSm-1, and OC ranged 0.42-0.64 percent. The available N content varies between 163.46 and 289.21 Kg ha^{-1}. The P content varied from 9.34-17.13 Kg ha-1. The content of potassium varied from 218 to 398.5 kg ha^{-1}. as per the results.

Dongre *et al.* (2018) reported that regardless of the year of organic agricultural techniques, no significant changes in pH or EC were identified. Organic farming increased the organic carbon content of the soil substantially. The population of bacterial, fungal, and other microorganisms was dramatically enlarged. With the organic farming situation, actinomycetes in soil were detected. Organic farming also resulted in greater soil microbial biomass carbon. Organic farming treatment with a duration of more than 5 years produced considerably greater soil biological characteristics than treatment with a duration Ravi of less than 5 years. Organic farming that lasts 3-5 years, organic farming that lasts 3 years, and inorganic farming.

Thakur *et al.* (2018) studied the physical and chemical characteristics of soil under various agroforestry models in the field of Indira Gandhi National Tribal University, Amarkantak, MP. The results show that the pH and EC status ranged from 5.79 to 6.12 and 108.5s to 233s, respectively, for 0-20 cm depth and 20-40 cm depth for all Agroforestry Models. TDS concentrations varied from 142 ppm to 166 ppm at 0-20 cm and from 77.3 ppm to 162 ppm at 20-40 cm and salt. In different Agroforestry Models, the concentration value ranges from 57.1 ppm to 115 ppm. The greatest Nitrogen and Phosphorus levels were seen in Agroforestry Model I (D. Sisso + Aonla + Wheat) at the depth of 0-20 cm, whereas the highest Potassium concentrations were detected in Agroforestry Model II (Teak + Guava + Soybean) at the depth of 20-40 cm. Nitrogen, Phosphorus, and Potassium levels exhibit mixed tendencies in relation to cultivation techniques and soil depth in models I and II, but there is a substantial difference between models I and II in model III. The current study concluded that including at least one component from the leguminous family into agroforestry systems is very desirable and beneficial in terms of improving the soil's health and fertility.

Zalte *et al.* (2018) collected data on natural resources such as soil fertility and current land use system aspects of the tribal region of Chikaldhara tehsil in Maharashtra state. The pH of Chikhaldhara soils was slightly acidic to slightly alkaline in nature and organic, based on soil fertility level, Carbon levels ranged from low to medium. Soils in this high rainfall location have lower available N and P content and medium available K content, but medium to higher accessible micronutrient status, namely Fe, Mn, Zn and Cu. As a result, effective land use according to land capacity is required by determining the restrictions for the production of available land. In order to use land resources efficiently and sustainably, as well as to modify management practices to increase soil fertility.

Ingle *et al.* (2018) researched variability of chemical characteristics of the soil and fertility in Bareli catchment in the Seoni district of Madhya Pradesh. Organic carbon and cation exchange capacity were considered to be significantly variable, whereas pH was reported to be the least variable. The available Nitrogen, Phosphorus, & Potassium determined to be insufficient to the moderately through peak, extreme to the very high & midrange as maximum, respectively, according to the spatial maps.

Pandey *et al.* (2019) studied the biochemical characteristics of soil in a Mollisol across multiple land management practices at the G.B. Pant University of Agriculture and Technology in Pant Nagar. Soil samples were gathered from 0-20cm depth and tested for various chemical characteristics. Soil pH (H_2O) ranged from 7.38 to 7.49, electrical conductivity ranged from 0.249 to 0.326 dSm^{-1} and CEC ranged from 22.21 to 36.51 C mol (p+) kg^{-1} soil. According to the findings, agroforestry-based systems were shown to be better in terms of chemical characteristics of soil, followed by field crops, horticultural crops and fallow (uncultivated land).

Manpoong *et al.* (2019) reported that changes in land use and poor soil management have resulted in significant land degradation across the world due to changes in soil physicochemical and biological processes. They evaluated the soil qualities of various land use system types. The soil pH was lower. More than 4.9 in all locations, suggesting that the surface soil was very acidic. Soil organic carbon (SOC) and total nitrogen (TN) levels varied from 2.02 to 2.81 percent and 0.22 percent, respectively. 0.3 percent for each. Soil moisture had a significant impact on soil organic carbon (SOC), total nitrogen (TN), and soil microbial biomass (SMBC). The largest soil microbial biomass carbon (SMBC) was found in NF soils, while the lowest was found in BF soils, with values ranging from 340 mg kg^{-1} to 345 mg kg^{-1}. RP had the greatest basal respiration (375 mg CO_2 m^{-2} hr^{-1}) and the lowest (224 mg CO_2 m -2 hr^{-1}). The results showed that land use change had a substantial (p0.05) influence on soil nutrient status and organic matter. Land use change also damaged native soil physicochemical and biological qualities, according to the findings. Suggesting prolonged fallow periods (<10 years) are likely to be helpful in facilitating the regeneration of some soil properties

Verma *et al.* (2019) studied the physicochemical features of soils from different land-use system, in Prayagraj (Allahabad), Uttar Pradesh. Samples were obtained from four distinct locations in the Allahabad district, namely ECC gaughat, Jhunsi, Karchhana, and Subedarganj, each of which was at least four kilometres apart. Some soil samples exhibited a greater water retention capacity and organic carbon value. When compared to farmed soils, they have average pH and EC values. Potassium levels in soil samples were found to be low. Physical qualities and parameters were average to medium for all soils, with little variance in chemical properties noted.

Dhakad *et al.* (2020) reported that Madhya Pradesh's soils have a usually low micronutrient nutritional content. Horizontal agricultural development prospects are relatively limited, thus future food, fodder, fruit, fiber, and fuel requirements must be satisfied by vertical expansion with rising crop production unit-1 area of soil. The intensification causes additional rise of micronutrients nutrients mining from the finite Zn, Fe, Cu Mn resources on soil to crop, which may lead to reasons such as insufficiency of all micronutrients to crop in addition to worsening that which is already there. Micronutrient deficits are well acknowledged as a severe challenge in maintaining crop production, animal and human health on Madhya Pradesh soil. We created micronutrient deficiency maps to examine the links between soil micronutrient concentration, availability, and agricultural yield in various Madhya Pradesh soils. This will help us better comprehend precise control of spatially varying soil micronutrient availability to crops.

GhosH *et al.* (2020) conducted a study on the soil properties of the Jaldapara National Park in West Bengal, India, assessed the various factors that affect its chemical composition. They found that the pH values in the top and subsoil layers varied from 7.97 to 4.21. The other factors that affect its chemical composition are the total nitrogen, phosphorus, and Sulphate content. The researchers found that the pH level in the topsoil layer was negative, while it was positive in the subsoil layer. The positive correlation between the organic matter and nutrients was also observed in the subsoil layer. The available soluble nutrients had a negative relationship with the pH.

Khatana *et al.* (2021) studied the soil physicochemical parameters in three different blocks of Malda district (West Bengal) at three different depths (0–15, 15–30, in order to analyse soil fertility status by evaluating the deficiency and toxicity of different soil nutrients. The analysis revealed a sandy loam to loam soil texture with a bulk density range of 1.33–1.81 Mg m^{-3} and a high WHC (44.71–59 percent). The pH of the soil varies from slightly acidic to slightly alkaline, with a mean value of 6.29–8.15 and the electrical conductivity is suitable for all crops and free of salt. with a standard deviation of 0.12–0.37 dS m^{-1}. Soil Organic Carbon was in the medium to high range (0.45–0.9 percent) compared to the standard, due to lesser decomposition of organic matter in the soil. Nitrogen (mean value range of 250.1–504 Kg ha^{-1}), Phosphorus (mean value range of 8.73–21.6 Kg ha^{-1}), and Potassium (mean value range of 161.3 – 279.6 Kg ha^{-1}) are sufficient, while Sulphur (13.23–31.32 Kg ha^{-1}) is deficient. Calcium and magnesium are sufficient (7.27 – 11.87 and 4.63 – 8.13 meq/100g, respectively). In terms of micronutrients, iron (5.8– 12.15 mg Kg^{-1}) and copper (0.16– 0.69 mg Kg^{-1}) levels are adequate, whereas zinc (0.16– 0.87 mg Kg^{-1}) levels are somewhat low.

Chapter-III

Material and Methods

The current study, **"Assessment of soil physicochemical properties and soil organic carbon pool under different land use systems in Chhindwara district of Madhya Pradesh,"** was carried out to examine the Soil Organic Carbon Pools under Different Land Use Systems and Physico-chemical Properties in Chhindwara District Madhya Pradesh.

The samples were taken from diverse land use systems and studied at the Soil Science-Soil and Water Conservation Laboratory, Rajiv Gandhi South Campus Barkachha, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

3.1 Description of site

3.1.1 Physiographic Location

The district of Chhindwara lies in the southwest part of the ' Satpura Range of Mountains.' The district has an area of 11,850 square kilometres and is located on the state's southern border, between North Latitudes 210 28' and 220 50' and East Longitudes 780 15' and 790 25'. The district is situated in the north by Narsinghpur and Hoshangabad districts, in the east by Seoni district, in the west by Betul district, and in the south by Maharashtra state.

The district is split into 11 Development Blocks and 12 Tahsils (Chhindwara, Tamia, Parasia, Jamai, Chourai, Amarwara, Sausar, Bichhua Umreth, Mohkhed, Harrai, and Pandhurna) (Chhindwara, Mohkhed, Tamia, Parasia, Jamai, Amarwara, Harrai, Chourai, Sausar Bichhua, and Pandhurna).

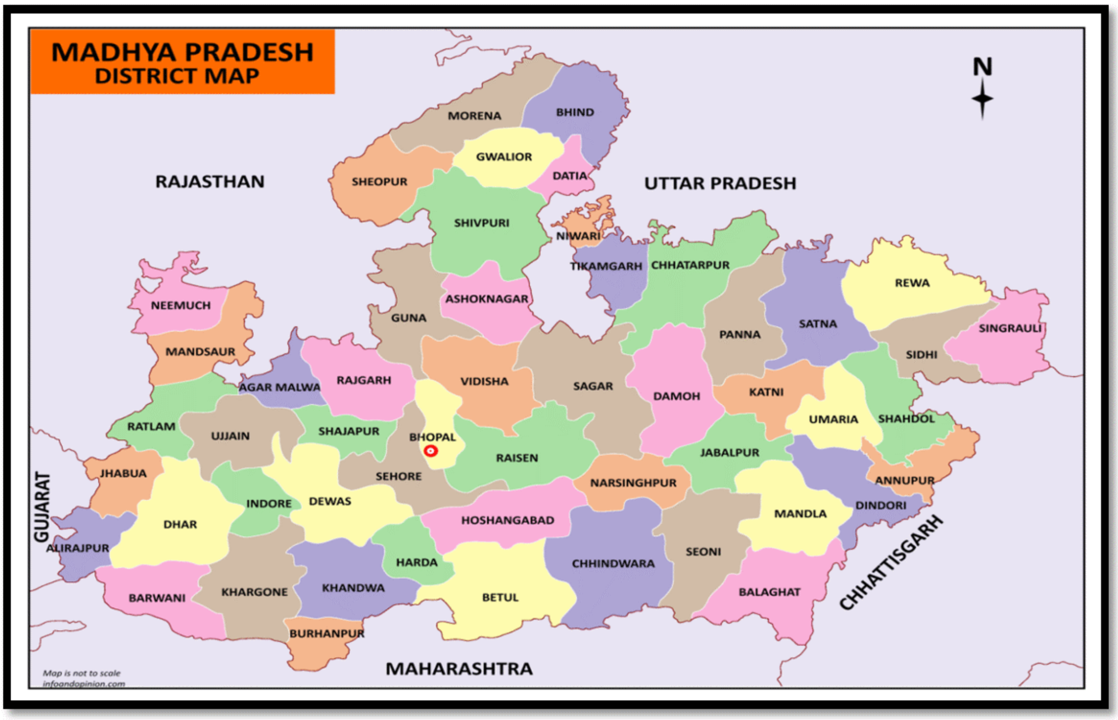

Fig. 1. District Map of Madhya Pradesh

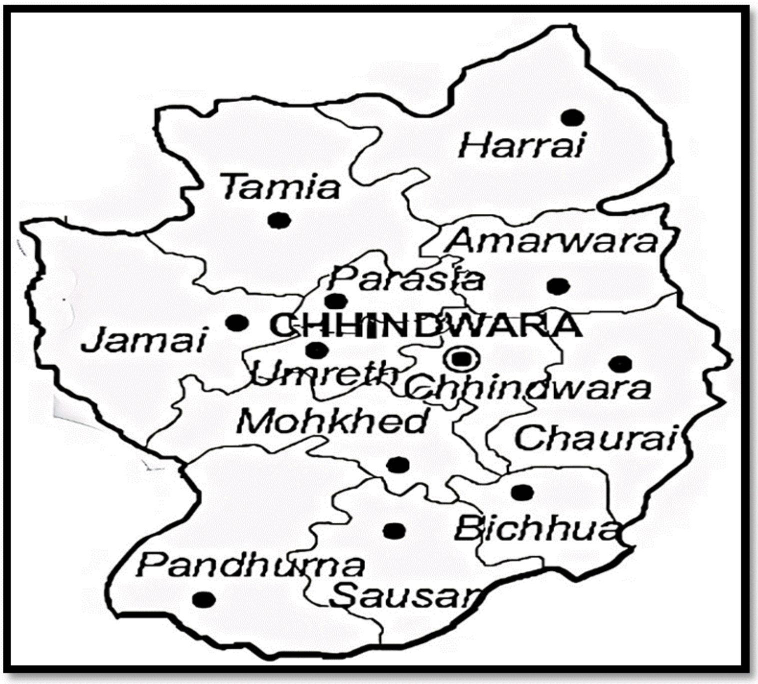

Fig. 2. Block Map of Chhindwara District Madhya Pradesh.

3.1.2 Weather & Climate

Except for the southwest monsoon season, the area's climate is characterised by a scorching summer and widespread dryness. There are 4 seasons in the year. The cold season lasts from December to February, while the hot season lasts from March to the middle of June. The south-west monsoon season lasts from the middle of June until the end of September. The post-monsoon or transition phase lasts from October through November. The average annual rainfall in Chhindwara is 1139.3 mm. The district receives the most rain during the south-west monsoon season, which runs from June to September. During the monsoon season, around 85.7 % of the annual rainfall falls. Only 14.3% of the yearly rainfall falls between October and May.

As a result, there is extra water for ground water recharge. During the southwest monsoon season alone. The average maximum temperature in May is 39.40 C, while the average lowest temperature in December is 9.80 C. The average annual minimum and maximum temperatures have been calculated to be 18.20 C and 30.60 C, respectively. The relative humidity typically surpasses 87% during the south-west monsoon season (August month), whereas the rest of the year is dryer. Summer is the driest season of the year, with relative humidity of less than 33%. May is the year's driest month. Wind velocity is greater during the pre-monsoon period than during the post-monsoon period. The greatest wind velocity was 9.5 km/hr in June and the minimum was 3.3 km/hr in November. The yearly average wind speed in is 5.4 km/hr.

3.1.3 Land use of the study site:

Location of soil sampling under cultivated land, fruit crop, Vegetable Crop, Fallow land and forest Land with respective soil type and elevation in the Chhindwara district of Madhya Pradesh.

3.2 Technical Programme

Experimental design	:	**Completely Randomized Design**
No. of land use systems	:	**5**
Depth of sampling	:	0-15, 15-30, (Total two depth)
Number of replications	:	05
Total number of samples	:	50

3.2.1 Collection of Soil Sample:

A total of 50 soil samples were randomly collected from different land use systems in the Chhindwara block of the Chhindwara district, stratified random sampling from each land use/land cover at the 0-15 and 15-30 cm layer. The samples were collected from various areas across the hamlet. A composite sample was cleansed of unwanted materials, homogenised, air dried at room temperature, crushed in a wooden mortar, sieved through a 2mm sieve, and kept in a covered plastic container for future examination.

3.3 Soil analysis

3.3.1 Soil bulk density

An electric balance was used to weigh a clean, dry pycnometer bottle. With the aid of a spatula, soil was added to the brim of the pycnometer. The pycnometer was tapped, and the empty chamber was filled with dirt once more. This process was done 5-7 times. The weight of the pycnometer with dirt was then taken. The soil was then taken from the pycnometer. A burette was filled with water, and water was dripped from the burette into the same pycnometer until the pycnometer was entirely full with water. The burette reading will provide the pycnometer's true volume.

Observations

1)	Weight of pycnometer	=	x g
2)	Weight of pycnometer + soil	=	y g
3)	Volume of pycnometer	=	z mL

$$\text{Bulk density } (Mgm^{-3}) = \frac{\text{Weight of soil } (y - x)}{\text{Volume of solid and pores } (z)}$$

3.3.2 Particle density

The pycnometer was cleaned and weighed. The Pycnometer was filled with water, weighed, and discarded. Then, 10 g of oven dried soil was placed in a beaker with a few cc of water, and it was heated until dry to remove the air. The pycnometer's remaining space was filled with water. The stopper was inserted, and the Pycnometer's surface was cleaned, dried, and weighted. The particle density was determined using the method described by Black et al, 1965.

Observation:

1. Weight of pycnometer bottle $=W_1$
2. Weight of pycnometer + water $=W_2$
3. Weight of pycnometer + water+ soil $=W_3$

Particle Density (Mg/m^{-3}) = $[10/(W_2+10)-W_3]$

3.3.3 Soil Porosity

Porosity was calculated by using Bulk density and Particle density value by using the formula

% Porosity = 1-BD/PD x 100

3.3.4 Water holding capacity

A keen box was used, and filter paper of the same diameter as the keen box was affixed to the inside base of the box and weighed. The dirt was placed in the keen box above the filter paper. By tapping the box 20 times, soil was filled. With the use of a knife, the upper surface was made almost horizontal after the earth was filled. The soil-filled box was then placed in a petridish filled with water and left for an hour. After removing the tiny box carrying the wet soil from the petridish and weighing it, the box with soil was placed in an oven to dry, and after drying, the weight of the box with dry soil was taken, and lastly a filter paper of the same size as that was placed. The sharp box was likewise placed in water for one hour and weighed both before and after wetness.

Observation:

1. Weight of Empty dish+ Filter Paper +Wet soil = C
2. Weight of Empty dish+ Filter Paper + air Dry soil =B
3. Weight of Empty dish+ Filter Paper = A

Water Holding Capacity (%) = (C-B) -(B-A)/(B-A) x100

$$\text{Water holding capacity (\%)} = \frac{\text{Weight of water held by a soil}}{\text{Weight of oven dry soil}} \times 100$$

3.3.5 Soil pH

A soil-water suspension in the ratio of 1:2.5 (10 g dirt with 25 mL distilled water) was made, and the pH was determined using a pH metre (Chopra and Kanwar, 1982).

3.3.6 Electrical conductivity

The electrical conductivity of soil was estimated using the soil water suspension created for pH testing. The soil suspension was allowed to settle until the supernatant was clear. Electrical conductivity was measured using an EC metre and expressed in dS m-1 (Sparks, 1996).

3.3.7 Organic carbon (Walkley and Black, 1934)

In a 500 ml conical flask, one gram of soil was placed. A ten-ml solution of 1 N K2Cr2O7 was added and stirred. The flask was then spin 2-3 times and let to stand for 30 minutes on an asbestos sheet to allow the reaction to proceed. Distilled water was used to dilute the suspension. Ten millilitres of 85 percent H3PO4 and one millilitre of diphenylamine indicator were added and titrated against 0.5 N Ferrous Ammonium Sulphate solution until the colour changed from violet to brilliant green. A blank titration was also performed.

Observation

$$\text{\% Organic 'C' in soil} = \frac{(B\text{-}T) \times 0.003 \times 10 \times 1 \times 100}{B \times \text{wt. of soil}}$$

Where,

Strength of $K_2Cr_2O_7$ used = 1N

Volume of $K_2Cr_2O_7$ taken = 10

B = Volume of 0.5 N FAS solution used for blank titration

T = Volume of 0.5 N FAS solution used for sample titration

3.3.8 Available nitrogen

Using a Kjeltec Semi-Auto Nitrogen Analyzer, the available nitrogen concentration in soil was determined using the alkaline potassium permanganate technique proposed by Subbiah and Asija (1956). The approach has been widely utilised to get a reliable assessment of nitrogen availability in soil due to its speed and repeatability.

PROCEDURE

A 5-gram soil sample was weighed and placed in a distillation tube. The sample was washed with 5 mL of distilled water to remove the dirt that had stuck to the flask's neck. The distillation tube was then connected to the instrument after it had been filled with 25 mL of 0.32 percent $KMnO_4$. In a 250 mL conical flask, 20 mL of a 2 percent boric acid mixed indicator was put under the receiver tube. The condenser was continually being replenished with tap water. 25 mL of 2.5 percent NaOH was sucked and added to the distillation tube. Following that, it went through a 15-minute distillation process. The ammonia-derived nitrogen is trapped in the boric acid, which becomes green as a result of this activity. The distillate was removed from the flask. The distillate was then titrated with 0.02N H_2SO_4 until the colour changed from green to the original wine-red colour (the colour of boric acid). Make a note of the finish point of the burette reading and run a blank at the same time.

Observation:

Available N (kg ha^{-1}) = (S-V) x0.02x14x10^6x2.24/1000x5

Where

S = Sample Titration reading

V = Blank Titration reading

3.3.9 Available phosphorus

Olsen's method was used to determine the soil's available phosphorus content (Olsen *et al.* 1954). To begin, reagent A was made from ammonium molybdate, antimony potassium tartrate, and H_2SO_4. Then, using reagent A, reagent B was created. In a 250 mL conical flask, a pinch of Darco G-60 and 40 mL of Olsen's reagent (0.5 M $NaHCO_3$) were added to 2.5 gramme of soil sample. A mechanical shaker was used to shake the contents for 30 minutes. After that, the suspension was filtered using Whatman No. 1 filter paper. In a 50 mL volumetric flask, 10 mL of filtrate was acidified with 2.5 M H_2SO_4 to pH 5.0, followed by 20 mL of distilled water and 4 mL of reagent B. After waiting 10 minutes, the intensity of blue colour was measured using a spectrophotometer at 730 nm. At the same time, a blank was run. A sample reading was taken after the typical reading.

Observation:

$$\text{Available P (kg/ha}^{-1}\text{)} = \frac{\text{Absorbance x dilution factor x2.24}}{\text{Slope of the Standard curve}}$$

3.3.10 Available potassium

The Flame Photometer (1 N ammonium acetate extract) technique was used to determine the soil's accessible potassium content (Hanway and Heidel, 1952). Five grammes of soil were agitated for five minutes in a 100 mL conical flask with 25 mL of 1 N ammonium acetate solution. After filtering the suspension using Whatman No. 1 filter paper, the potassium content in the filtrate was determined using a flame photometer. A sample reading was taken after the typical reading.

Observation:

Dilution factor = 25 / 5 = 5 times

Concentration of K in the sample from standard curve against the reading R = C

$$\text{Available K (kg ha}^{-1}\text{)} = \text{C x dilution factor x 2.24}$$

$$= \text{C x 5 x 2.24}$$

$$= \text{C x 11.2}$$

3.3.11 Available sulphur

The quantity of accessible sulphur in the soil was determined using the turbidity technique (Chesin and Yein, 1952). 10g of dirt and 50 mL of 0.15 percent CaCl2 solution were placed in a 100 mL conical flask. After shaking for 30 minutes on a shaker, the suspension was filtered using Whatman No. 42 filter paper. The aliquot was then placed to a 25 mL volumetric flask containing 1 g sieved $BaCl_2$ crystals and stirred for 1 minute. One ml of 0.25 percent gum acacia solution was added to bring the volume up to the mark. After one minute of shaking, the turbidity was measured with a spectrophotometer equipped with a blue filter at 420 nm after 25 to 30 minutes. Simultaneously, a blank was created in the same way. A sample reading was taken after the typical reading.

Observation:

10g of soil sample was diluted in 50ml of 0.15% calcium chloride solution.

Hence, dilution factor = 50/10 = 5 times

10ml of aliquot was taken in 25ml volumetric flask

Hence, dilution factor = 25/10 = 2.5 times

Therefore, total dilution factor (DF) = 5 x 2.5 = 7.5 times.

Concentration of sulphur in soil sample:-

Hence,

$$\text{Concentration of S (ppm)} = \frac{\text{y (\% absorbance of soil sample)}}{\text{m (slope of standard curve)}}$$

Therefore,

$$\text{Available S (ppm) in soil} = \frac{\text{Absorbance}}{\text{Slope of standard curve x Dilution factor}}$$

Table 3.2 Characterization of soil test values for different nutrients.

Nutrient	Rating of the soil testing values		
	Low	**Medium**	**High**
Organic carbon (%)	< 0.5	0.5 - 0.75	> 0.75
Available Nitrogen (kg ha^{-1})	< 280	280 – 560	> 560
Available Phosphorus (kg ha^{-1})	< 10	10 – 25	> 25
Available Potassium(kg ha^{-1})	< 118	118 – 280	> 280
Available Sulphur (mg kg^{-1})	<10	10-20	> 20

3.3.12 SOIL ORGANIC CARBON POOL:

Walkley and Black (1934) determined soil organic carbon (SOC) using 12N, 18N, 24 N, and 36 N H2SO4, implying that the recovery factor of 1.298 represents the total SOC pool. This fraction was divided into four pools: very liable (pool I: CVL), labile (pool II: CL), less labile (pool III: CLL), and non-labile (pool IV: CNL). Pools I and II together represent the active pool [Active pool = [(pool I + pool II)] of organic carbon in soils (Chan et al. 2001) using 5, 10, and 20 ml of concentrated (36.0 N) H2SO4, resulting in three acid-aqueous solution ratios of 0.5:1, 1:1, and 2:1 (corresponding to 12.0, 18.0 and 24.0 N of H_2SO_4, respectively) The quantity of C thus calculated allowed the entire soil organic carbon to be divided into four separate pools.

According to their decreasing order of oxidizability:-

Pool I (CVL very labile) - Organic C oxidizable by 12.0 N H_2SO_4

Pool II (CL labile) - The difference in C oxidizable by 18.0 N and that by 12.0 N H_2SO_4

Pool III (CLL less labile) - The difference in C oxidizable by 24.0 N and that by 18.0 N H_2SO_4

Pool IV (CNL non labile) - The difference between C and oxidizable by 24.0 N H_2SO_4

The pool I and II together represent the active pool [active pool = (pool 1 + Pool II)] while pool III and pool IV together constitute the passive pool [Passive pool= (pool III+ Pool IV)] of organic C in soils (**Chan *et al.* 2001**)

TOC Procedure:-

In a 500ml conical flask, place 1gm of soil. Pipette out 10ml of 1N $K_2CR_2O_7$ with a bulb pipette and add to flask contents, thoroughly mixing them in. Then, using a measuring cylinder, add 10 ml of concentrated H_2SO_4 of 12N, 18N, 24N and 36N to the flask and gently swirl it. Keep the flask for 30 minutes now. Then, using a measuring cylinder with a capacity of 500ml, add 200ml distilled water and twist the flask to combine them. It will produce an orange or yellow colour. Pour 0.5 N Ferrous Ammonium Sulphate Solutions into the burette. Using a measuring cylinder or a pinch of NaF, pour 10ml orthophosphoric acid into the flask. After that, add 1ml of diphenylamine indicator to the flask contents and well mix. Titrate the flask contents immediately with 0.5 N Ferrous Ammonium Sulphate Solution. During titration, a light violet (blue) colour will appear first, followed by a decrease of FAS till the colour changes from violet (blue) to green. Run a blank without soil at the same time.

Observation :-

$$\textbf{TOC\%} = \frac{\text{titrated blank value - titrated sample value x 0.3 x 0.46}}{0.588 \times 1.334}$$

$$\textbf{SOCF\%} = \frac{\text{Pool II C oxidised by 18.0 N - Pool I C oxidised 12.0 N } H_2SO_4}{\text{Pool III C oxidised by 24.0 N - Pool II C oxidised 18.0 N } H_2SO_4}$$

Pool IV C oxidised by 36.0 N - Pool III C oxidised 24 N H_2SO_4

Pool C oxidised - Pool 24 N H_2SO_4

3.4 Statistical analysis and interpretation of data

To get accurate findings, the experimental data on soil were statistically evaluated using the approach provided by Gomez and Gomez (1984). The significance test was performed using 'F' table values at a 5% level of significance.

Chapter-IV

Result and Discussion

The present study entitled "Assessment of soil physicochemical properties and soil organic carbon pool under different land use systems in Chhindwara district of Madhya Pradesh" was carried out during the year 2020-22. The samples were taken from diverse land use systems and studied at the R.G.S.C, Barkachha, Laboratory for SWC, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

The main purpose of this chapter is to determine the degree of variation seen in different land use systems' depth levels. The soil's physicochemical properties, nutrient content, and organic carbon pools are all determined. To get accurate conclusions, the data collected during the investigation was statistically evaluated. This chapter explains the differences in reactions caused by varying experimental factors on various components. The results has been categorized in following different heads.

1. Depth wise Soil Physical Properties under different land-use Systems of Chhindwara district.
2. Depth wise Soil Chemical Properties under different land-use Systems of Chhindwara district.
3. Depth wise Soil Nutrient Availability of Major Nutrients under different land-use Systems of Chhindwara district.
4. Depth wise Soil Organic Carbon Pools under different land-use Systems of Chhindwara district.

Table 4.1 Soil Physical properties at different depth under various land use systems.

Treatments	Particle Density		Bulk Density		Porosity		Water Holding Capacity	
Soil Depth	**0-15cm**	**15-30 cm**	**0-15cm**	**15-30cm**	**0-15cm**	**15-30cm**	**0-15cm**	**15-30cm**
Cultivated	2.79	2.77	1.53	1.57	44.88	42.96	40.65	41.40
Fallow	2.85	2.68	1.43	1.49	49.44	44.43	41.30	42.24
Forest	2.71	2.85	1.42	1.40	47.15	50.68	41.07	41.84
Fruit	2.77	2.82	1.39	1.43	49.86	49.17	41.98	42.50
Vegetables	2.82	2.77	1.47	1.29	46.83	53.31	42.23	43.56
CD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SE(m)	0.08	0.06	0.07	0.09	2.35	3.11	0.95	1.21

4.1.1 Particle density (PD)

Table no. (4.1) displays information on the soil's particle density. Data analysis showed that depth and systems had a significant impact on the soil's particle density. At different depths, the soil Particle Density ranged from 2.68 to 2.85 Mg m^{-3}. Maximum Particle Density (2.85 Mg m^{-3}) was recorded at a depth of 0-15cm in the Fallow land use system, whereas the minimum PD (2.71 Mg m^{-3}) was measured at a depth of 0-15cm in the Forest land use systems. At 15-30cm depth, the vegetable land use system (2.68 Mg m^{-3}) had the least PD, whereas the system of cultivated land use had the most (2.85 Mg m^{-3}). Additionally, the data demonstrates that particle density increases with depth.

4.1.2 Bulk density (BD)

Table no. (4.1) displays the density of the soil. Data analysis showed that there was no statistically significant relationship between the soil's bulk density and the various land use patterns. At different soil levels, the Bulk Density varied from 1.29 to 1.57 Mg m^{-3}. The highest BD was (1.53 Mg m^{-3}) measured in soil from a cultivated land use system at depths ranging from 0 to 15 cm. At depth of 0-15cm, the soil of a fruit land use system had the lowest BD (1.39 Mg m^{-3}) reported. At 15-30 cm depth, the vegetable land use system (1.29 Mg m^{-3}) had the least Bulk Density, whereas the cultivated land use system had the greatest BD (1.57 Mg m^{-3}). Additionally, according to the statistics, bulk density increases with depth.

4.1.3 Porosity

In Table no. (4.1) information on the soil's porosity is displayed. A thorough analysis of the data showed that the depth and various land use regimes had no discernible effect on the soil porosity. The porosity of the soil varied from 42.96 to 53.31 percent depending on its depth. The largest porosity (49.86 percent) was found in soils of the Fruit land use system at depths ranging from 0 to 15 cm. At a depth of 0-15 cm, the soil of cultivated land use system had the lowest porosity (44.88 percent). At a depth of 0-15 cm, the soil of cultivated land use systems (42.96 percent) had the lowest porosity, while the soil of vegetable land use systems (53.31 percent) had the maximum porosity.

4.1.4 Water Holding capacity (WHC)

Table no. (4.1) displays information on water-holding capability of the soil. The WHC of the soil changed greatly with depth, as was evident from a careful analysis of the data. The Water Holding Capacity varied from 40.65 to 43.56 percent at various depths of soil. The highest WHC (42.23 percent) was found in vegetable land use system soils at depths ranging from 0 to 15 cm. At a depth of 0-15 cm, the lowest WHC (40.65 percent) was measured in soil from a cultivated land. At a depth of 15-30cm, soil from cultivated land use systems (41.40 percent) had the lowest WHC, while soil from vegetable land use systems (43.56 percent) had the greatest WHC. The findings also show that the water holding capacity of the soil decreased with depth.

Table : 4.2 Soil Chemical properties at different depth under various land use systems

Treatments	pH		EC		Soil Organic Carbon		Total Organic Carbon	
Soil Depth	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
Cultivated	6.50	6.80	0.23	0.21	0.78	0.99	1.033	1.313
Fallow	6.16	6.34	0.24	0.25	1.03	1.40	1.367	1.851
Forest	5.88	5.80	0.25	0.21	0.67	0.92	0.895	1.217
Fruit	6.60	6.22	0.26	0.28	0.83	0.89	1.095	1.183
Vegetables	6.52	6.56	0.31	0.27	0.78	0.77	1.041	1.018
CD	N/A	N/A	N/A	0.04	N/A	0.33	N/A	0.442
SE(m)	0.20	0.24	0.025	0.01	0.08	0.11	0.109	0.146

4.2.1 Soil reaction (pH)

Soil pH is sometimes referred to as the master soil variable since it regulates almost all aspects of soil's biological and chemical function. Metal dissolution, precipitate, segregation, adsorption, & resorption are some of these processes, and microbial activity. Soil pH is informative and widely studied chemical parameters of soil that has a direct impact on plant development. It has a significant impact on the availability of components to plants. Table no. (4.2) contains data based on the soil's pH. A thorough study of the data showed that varied land use patterns significantly altered the pH of the soil. The pH ranged from 5.80 to 6.80 depending on the soil's depth. The pH value that was highest (6.80) was found in soils from cultivated land systems at (15-30 cm) depth. At a depth of 15-30 cm, the lowest pH (5.80) was measured in the Forest land system. Among the systems at 0-15 cm depth, the Forest land use systems (5.88) had the lowest pH, while the Fruit land use system (5.88) had the highest (6.60) at a depth of 0-15 cm.

4.2.2 Electrical conductivity (EC)

Table no. (4.2) gives details regarding the soil's EC. A thorough analysis of the data showed that the EC of soil did not significantly change with various land use patterns. The EC at different soil depths ranged from 0.21 to 0.31dS m^{-1}. At 0-15cm depth, the greatest EC (0.31 dS m^{-1}) was measured in soils from a vegetable land use system. The minimum EC (0.23 dS m^{-1}) in a cultivated land use system was measured at a depth of 0–15 cm. 15 to 30 cm depth, the fruit land use system had the greatest EC (0.28 dS m^{-1}), whereas the cultivated and forest land use systems had the lowest EC (0.21 dS m^{-1}).

4.2.3 Soil Organic Carbon (SOC)

The organic carbon contents percent of soil changed as indicated in table no. (4.2), varied significantly with various land use patterns and depth. Soil organic carbon levels varied from 0.67 to 1.40 percent depending on depth. At (0-15 cm) depth, the greatest organic carbon (1.03 %) was found in soils from a fallow land use system. The lowest organic carbon content (0.67 percent) was observed in (0-15 cm) of the Forest land use system. At 15-30 cm depth, the soil of fallow land use systems (1.40 %) had the most organic carbon, whereas vegetable land use systems (0.77 %) had the lowest organic carbon. Soil organic carbon is intertwined with soil fertility and agricultural yield potential. The physicochemical characteristics of High levels of organic matter in soil are beneficial (Garcia Gil *et al.* (2004), Veeresh *et al* (2003). In most agricultural soils, organic matter can be increased by maintaining remnant on the surfaces, alternating plants and vegetation or shrubs, including covering plants in crop rotations, or introducing biological leftovers like livestock manure or artificial fertilizers. The soil biomass load in plant litter could be too responsible for the higher organic carbon content.

4.2.4. Total Organic Carbon (TOC)

Table no. (4.2) Total Organic Carbon data show a considerable variation in soil organic carbon concentration with regard to various land use regimes. The percentage of total organic carbon varied between 0.89 and 1.85 at different soil depths. The region with the greatest overall organic carbon content (1.85%) was fallow land soils (15-30cm). At a depth of (15-30 cm), the forest land use system crop had the least amount of total organic carbon (1.01 percent). At 0-15cm depth the forest land use system (0.89 percent) had the lowest total organic carbon content, while the Fallow land use system (1.36 percent) had the greatest total organic carbon content. At 0-15 cm depth, the agricultural, vegetable, and fruit land use system were found in medium category, while the forest land use system was determined to be in the low category. At 15-30 cm, in contrast to the rest of the land use systems, vegetable land use systems had a low percentage of total organic carbon. As soil depth grew, the organic carbon level drastically decreased.

Table 4.3 Soil Major available nutrient content at different depth under various land use systems

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur	
Soil Depth	0-15cm	15-30 cm	0-15cm	15-30 cm	0-15cm	15-30 cm	0-15cm	15-30 cm
Cultivated	263.42	388.86	12.41	14.17	259.84	313.60	8.08	8.45
Fallow	158.05	208.23	6.59	9.11	168	203.84	8.12	8.07
Forest	351.23	406.46	17.35	19.52	257.60	295.68	8.05	8.18
Fruit	248.37	313.60	20.52	21.21	284.48	338.24	7.73	7.57
Vegetables	361.26	416.46	21.83	22.81	378.56	467.84	7.85	7.22
CD	120.5	98.24	2.85	3.66	49.04	129.08	N/A	0.71
SE(m)	39.85	32.49	0.94	1.21	16.21	42.68	0.27	0.23

4.3.1 Available Nitrogen.

Table no. (4.3) reveals details on the soil's available N content. A thorough analysis of the data indicated that the soil's available nitrogen concentration fluctuated non-effectively using various land use management techniques The available nitrogen ranged from 158.05 to 416.46 kg ha-1 at different soil depths. In vegetable field soils, the largest amount of nitrogen (416.46 kg ha^{-1}) was measured (15-30 cm). The minimal accessible nitrogen level (158.05 kg ha^{-1}) was recorded on fallow land at a depth of 0–15 cm. At a depth of 15 to 30 cm, fallow land (208.23 kg ha^{-1}) had the least nitrogen accessible across the systems vegetable land had the highest depth (0-15 cm) (361.26 kg ha^{-1}). The available nitrogen content at a depth of 0-15 cm Cultivated, Fallow, and Fruit land had low nitrogen availability, while Forest and vegetable land had the highest nitrogen availability. Fallow land had the lowest available nitrogen in 15-30 cm depth, while Cultivated, Forest, Vegetable, and Fruit land had the highest content. The nitrogen content of all plants' soils was in the middle range. It gradually decreased as soil depth increased.

4.3.2 Available Phosphorus.

Table no. (4.3) demonstrates the soil's available phosphorus concentration. The available P content of the soil changed significantly with different land-use systems, according to a careful analysis of the data. The range of accessible phosphorus was 6.59 to 22.81 kg ha^{-1} depending on soil depth. The greatest available phosphorus content (22.81 kg ha^{-1}) was measured in vegetable field soils at depths ranging from 15 to 30 cm. The least accessible phosphorus level (6.59 kg ha^{-1}) was determined on fallow land at a depth of 0–15 cm. One of the systems is agricultural land (21.83 kg ha^{-1}) had the most available phosphorus (at 0-15 cm depth), while Fallow land had the lowest (9.11 kg ha^{-1}) at 15-30 cm depth, followed by cultivated land (14.17 kg ha^{-1}). The table perfectly indicates that, with the exception of fallow land at both depths (0-15, 15-30 cm), available phosphorus is low as compared to the Other land-use systems, whereas all Other land-use systems are in the medium range Of the phosphorus availability.

4.3.3 Exchangeable Potassium.

Table no. (4.3) shows data on the potassium exchangeable content of the soil. A thorough analysis of the information revealed that the exchangeable potassium concentration of soil varied significantly with different land-Use system. The exchangeable potassium at different soil depths ranged from 168 to 467.84 kg ha^{-1}. The most Exchangeable K (467.84 kg ha^{-1}) Was found in vegetable land soils at depths ranging from 15 to 30 cm. At a depth of 0-15 cm. On fallow land, the lowest exchangeable potassium content (168 kg ha^{-1}) was recorded at a depth of (0–15 cm) fallow land. Vegetable land (378.56 kg ha^{-1}) At 0–15 cm depth, had one of the most exchangeable potassium among the systems, whereas Fallow land had the lowest at 15-30 cm depth. The exchangeable potassium level in all planted soils ranged from low to high. It gradually decreased as soil depth increased.

4.3.4 Available Sulphur

Table no. (4.3) provide details on the amount of accessible sulphur in the soil. The accessible sulphur content of soil does not considerably change with different land-use Systems, according to a detailed analysis of the data. The available sulphur concentration in the soil ranged from 7.22 to 8.45 mg kg^{-1} at different soil depths. The highest Available S (8.45 mg kg^{-1}) was found in cultivated land soils (15-30 cm), followed by soils from forests (8.18 mg kg^{-1}). The least accessible sulphur content (7.22 mg kg^{-1}) at a depth of 15 to 30 cm was measured during vegetable land. Fruit land (7.73 mg kg^{-1}) had the lowest available sulphur at 0-15 cm depth, whereas cultivated land had the greatest at 0-15 cm depth (8.08 mg kg^{-1}). The available sulphur level in all planted soils was in the low range. It gradually increased as soil depth deepened.

Table 4.4 Depth wise Soil Organic Carbon Pools under different land Use Systems of Chhindwara district.

Treatments	VLC		LC		LLC		NLC	
Soil Depth	**0-15cm**	**15-30 cm**	**0-15cm**	**15-30 cm**	**0-15cm**	**15-30 cm**	**0-15cm**	**15-30 cm**
Cultivated	1.43	0.35	0.64	0.22	0.69	0.19	0.67	0.04
Fallow	1.35	0.31	0.57	0.20	0.68	0.18	0.66	0.04
Forest	1.33	0.26	0.67	0.19	0.71	0.20	0.71	0.03
Fruit	1.33	0.27	0.54	0.16	0.61	0.18	0.63	0.03
Vegetables	1.37	0.25	0.61	0.19	0.62	0.17	0.62	0.04
CD	0.051	0.04	0.05	N/A	0.025	N/A	0.032	0.01
SE(m)	0.017	0.013	0.017	0.016	0.008	0.009	0.011	0.003

Soil is a primary carbon reservoir inside the agricultural carbon cycle, and it also has the potential to operate as a carbon dioxide sink in atmosphere. Two main elements, net primary production input and decomposition rate, control the quantity of soil organic carbon. Organisms in the ground control the transformation of plants. Remains and roots compost, creatures inside the ground use the energy in organic C.

In addition to the atmosphere, terrestrial ecosystems similarly store carbon. Roughly 2.3-3.1 times as much carbon is deposited in the world's soils than plants. One of the five major biomass reservoirs in the soils is organic carbon agro-forestry sector's Land Use and Land Use Change. Soil degradation quickly depletes it. Soil respiration rates and (SOC) pools are affect by the land-Use change. A non-hydrolysable C pool might shed light on how different land use strategies might contribute to carbon stability was used to determine the proportion of active (Very Labile Carbon + Labile Carbon) and passive (Less Labile Carbon + Non-Labile Carbon) carbon pools (Chan *et al.* 2001). Utilizing various alkaline solution of (12-N), (18-N), (24-N), and (36-N)

H_2SO_4', the capacity of various pools to oxidise was extracted in decreasing order. They are as follows;

4.4.1 'Very Labile Carbon' (VLC)

Table no. (4.4) shows that the per very labile carbon Soil content varied Significantly with different land-use systems & depths. At different depths of soil, the extremely labile carbon between 0.25 and 1.43 percent. In soils from cultivated land, the highest concentration of extremely labile carbon (1.43 percent) was discovered (0-15 cm). Vegetable field was found to contain the smallest amount of extremely labile carbon (0.25 percent) at depths of 15 to 30 cm. The minimum very labile carbon (0.25%) was found in vegetable land at depths of 15-30 cm. The lowest level of very labile carbon was found in the 0-15 cm depth in fruit land systems (1.33%), while the highest level of 15-30 cm depth was found in the cultivated land system (0.35%). The very labile carbon decreased progressively as increased soil depth.

4.4.2 'Labile Carbon' (LC)

The proportion of labile carbon as seen in table no. (4.4), soil composition differed significantly with different land-use patterns and depth. At distinct depths of soil, the labile carbon ranged between 0.16 and 0.67 percent the highest quantities of labile carbon (0.67 percent) are found on forested areas at a depth of (15-30cm). The minimum level of labile carbon (0.16 percent) was measured in a Fruit crop field at a (15-30 cm) depth. While highest labile carbon (0.22%) of 15-30 cm depth was found in cultivated land system. Lowest labile carbon (0.54%) of (0-15cm) depth was found in Fruit land system. The labile carbon reduced significantly as soil depth increased.

4.4.3 'Less labile carbon' (LLC)

The kind of soil changed Significantly, as demonstrated in table no. (4.4), with various land-use systems and depth. The less labile carbon varied from 0.17 to 0.71 percent depending on soil depth. Soils have the largest amount of less labile carbon (0.71 percent), the less labile carbon ranged from 0.17 to 0.71 percent. The highest concentration of less labile carbon (0.71 %) was found in soils of forest land at a depth of 0-15 cm. the lowest labile carbon (0.17 %) was found on vegetable land at a (15-30cm) depth. Fruit land (0.61 %) had the least labile carbon among the systems studied at 0-15 cm depth, followed by vegetable land (0.62 percent) and the highest was found in the forest (0.20%) at (15-30cm) depth. Less labile carbon reduced progressively as soil depth increased.

4.4.4 'Non labile carbon' (NLC)

As demonstrated in table no. (4.4), the non-labile carbon content of soils varied dramatically with different land use regimes and depth. The non-labile carbon varied from 0.03 to 0.71 percent at various soil depths. The soil of the forest resources system had the largest amount of non-labile carbon (0.71 percent) at a depth of 15-30 cm, the least non-labile carbon (0.03 %) was found on forest land. Vegetable land (0.62 %) had the lowest non-labile carbon at 0-15 cm depth, followed by fruit crop land (0.63 %), while cultivated land had the highest non-labile carbon at 15-30 cm depth (0.04%).

Chapter-V

Summary and Conclusion

The present study entitled **"Evaluation of soil fertility and SOC pools under different land-use systems in the Bhandara District of Maharashtra"** was conducted at Rajiv Gandhi South Campus, Banaras Hindu University. Soil samples were obtained from Bhandara district of Maharashtra from different land-use systems at two depths (0-15 and 15-30) and analyzed in the Soil and Water Conservation Laboratory, R.G.S.C. Barkachha. The Randomized Block Design was used to statistically examine data collected in numerous areas. This chapter summarizes and concludes the facts and outcomes gathered during the testing period.

- The maximum particle density (3.21 Mg m^{-3}) was recorded in soils of cultivated land at depth of 15-30 cm. The particle density increased with depth.
- The largest bulk density (1.57 Mg m^{-3}) was found in cultivated field soils at depths of 15-30 cm. The bulk density increased as depth increased.
- The highest water holding capacity (41.99 %) was recorded in soils of fruit crop followed by fallow land (41.51 %) at depth of 15-30 cm.
- The highest porosity (51.7 %) was recorded in soils of cultivated land at depth of 0-15 cm. The porosity increased with depth.
- The highest pH (7.44) was recorded in soils of fruit crop land at depth of 0-15 cm. The minimum pH was recorded in fallow land of at a depth of 15-30 cm.
- The most of EC (0.39 dS m^{-1}) was recorded in soils of fallow land (0-15 cm). Amongst the systems at 0-15 cm depth forest land (0.12 dS m^{-1}) showed

lowest EC, while, highest at 15-30 cm depth was found in fruit crop land (0.25 dS m^{-1}).

- The maximal organic carbon (1.93 %) was recorded in soils forest land (15-30 cm). The organic carbon content at 0-15 cm depth cultivated field was found in medium category, while it was low in vegetable field. The organic carbon progressively increased with increase in soil depth.

- The upper limit of total organic carbon (2.43 %) was recorded in soils of forest land at (0-15 cm). The minimum total organic carbon (0.6 percent) was recorded in vegetable crop field at a depth of 15-30 cm. The organic carbon progressively decreased with increase in soil depth.

- The highest available nitrogen (461.61 kg ha^{-1}) was recorded in soils of forest land (0-15 cm). The nitrogen content in soils of all plantations was under medium category. It progressively decreased with increase in soil depth.

- The most accessible phosphorus concentration (11.85 kg ha^{-1}) was measured in forest land soils (0-15 cm). At a depth of 15-30 cm, the minimal accessible phosphorus level (5.82 kg ha-1) was measured in fallow ground. The available phosphorus reduced significantly as soil depth increased.

- The maximum exchangeable potassium (680.96 kg ha^{-1}) was recorded in soils of fruit crop (0-15 cm). The minimum exchangeable potassium content (244.16 kg ha^{-1}) was recorded in fallow land at a depth of 15-30 cm. It progressively decreased with increase in soil depth.

- The highest available sulphur (8.68 mg kg^{-1}) was recorded in soils of cultivated land (15-30 cm) followed by forest land (8.26 mg kg^{-1}). The minimum available sulphur content (6.17 mg kg^{-1}) was recorded in fallow land at a depth of 0-15 cm. It progressively increased with increase in soil depth.

- The maximal very labile carbon (1.42 %) was recorded in soils of cultivated land (0-15 cm). Amongst the systems at 0-15 cm depth fallow field (1.28 %) showed lowest very labile carbon, followed by forest (1.38 %) and in 15-30 cm depth maximum was recorded in cultivated field (0.29 %). The very labile carbon progressively decreased with increase in soil depth.

- The highest labile carbon (0.66 %) was recorded in soils of cultivated land (0-15 cm). The minimum labile carbon (0.11 %) was recorded in forest field at a depth of 15-30 cm. The labile carbon progressively decreased with increase in soil depth.

- Maximum less labile carbon (0.85 %) was recorded in soils forest land (0-15 cm). The minimum less labile carbon (0.13 %) was recorded in cultivated land at a depth of 15-30 cm. Amongst the systems at 0-15 cm depth vegetable crop field (0.64 %) showed lowest less labile carbon, followed by fruit crop and in 15-30 cm depth maximum was recorded in forest and vegetable crop field. The less labile carbon progressively decreased with increase in soil depth.

- Soils and forest land have the highest non-labile carbon content (0.80 percent) (0-15 cm). In cultivated ground, the least non-labile carbon (0.03 percent) was measured at a depth of 15-30 cm. At 0-15 cm depth, fallow field had the lowest non-labile carbon, followed by vegetable crop field, while at 15-30 cm depth, forest and fallow land had the most. The non labile carbon progressively decreased with increase in soil depth.

According to the findings of the study, the OC, available N, P, K, and S levels in soils were enough. Furthermore, the higher layers of soil had a high exchangeable potassium level and a medium available phosphorus amount. This demonstrates that the district's land use systems have a high potential for boosting potassium and phosphorus levels to a lower depth. TOC and all four pools of soil organic carbon were all greater in forests than in other land use types within a 0-30 cm soil profile (cultivated, fallow, fruit crop field and vegetable crop field). The proportion of Active Carbon Pool (VLC and LC) in all land use categories was larger than the fraction of Passive Carbon Pool (LLC and NLC), showing that deposited carbon may be rapidly lost after land-use changes. However, forest land-use parts had the largest fraction of passive carbon Pools, showing that the stored soil organic carbon was more permanent. As a result, it is reasonable to conclude land-use types affect both Active and Passive C pooLs in distinct soil surface, and In order to effectively exploit soil's C sequestration potential, the dynamics of SOC turnover in the soil profile with land use management strategies should be investigated further.

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