Original Research Article

Impactof Different Land Use Practices on size of Soil Aggregates And its Mean Weight Diameter Under Vertisols of Central India

Abstract:

The present study was carried out at JNKVV, Jabalpur ($23^0$10' N latitude, $79^0$57' E longitudes and at elevation 393.0 meters above mean sea level). This study was carried out in 2019 that laid out in split plot design with nine main treatments of land use practices (forest land, perennial forage land, uncultivated land, aonla orchard, rice-wheat system, soybean-wheat system, guava orchard, mango orchard and citrus orchard) and three sub-plot treatments of soil depths (0-20, 20-40 and 40-60 cm) which were replicated three times. A total of 81 soil samples were subjected to determination of different size (> 5.0, 2.0-5.0, 1.0-2.0, 0.50-1.0, 0.25-0.50, 0.10-0.25 and <0.10 mm) water stable soil aggregates and mean weight diameter of soil aggregates. Results revealed that land use practices and soil depths significantly affect the mean weight diameter of soil aggregates, distribution of different size soil aggregates. It was noted that irrespective of soil depths, proportions of macro-aggregates (>0.50 mm size) and mean weight diameter were highest under forest land and lowest in soybean-wheat system. However, number of micro-aggregates (< 0.50 mm) increased with soil depths and macro-aggregates and mean weight diameter of soil aggregates were highest at 0-20 cm depth.It can be concluded that extent of soil disturbance significantly alters the proportion of macro-aggregates (>0.50 mm size) and mean weight diameter of water stable soil aggregates with higher in undisturbed (forest, uncultivated and perennial forage) land uses and lower in crop lands which decreased with increase in soil depths.

Key words: Land use, Soil aggregates and Mean weight diameter

Introduction:

Land use comprises the management and adjustment of natural environment or wasteland into assembled environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods. Land use by means of human beings has anextensive history, first developed more than 10 thousand years ago. It has been defined as "the purposes and activities through which people interact with land and terrestrial ecosystems" and as "the whole of arrangements, activities, and inputs that individuals undertake in a certain land type." Land use is one of the most important drivers of global environmental change. Ellis *et al*., 2019.Land use and land cover (LULC) dynamic forces offer vital facts for the representatives to reunite forestry management practice and crop cultivation in the agroforestry landscape ParetaandPareta, 2011.

In a broad logic of ecosystem, land denotes to landforms, climate, edaphic characters, plants, and water resources. Variations in LULC date back to early history and be situated the direct and indirect moment of human activities on the participatingfundamentals of these resources Wulder*et al*., 2016.The undesirablemodificationssubsidizesuggestively to the damageto biodiversity and hostile climate change, mostly due to the change of forestry to farmingareas, human settlement, and infrastructure Duguma*et al*., 2019.

Anthropological activitieshaveexaggeratedabout 75–83% of the global terrestrial land surface and has degraded about 60% of the ecosystem services through time and the human footmark has increased by just 9% Venter *et al*., 2016. These modifications could have initiallyhappenedby means of the burning of vegetation areas to improve the natal of agriculture, resultant in the widespreaddisforestation and deprivation of soil's terrestrial exterior that lasts today with a greater extent and rate through the world Arevalo*et al*., 2014. The LULC dynamic forcesfixed with the growing human residents are disturbingworldwide atmospheric concentrations of greenhouse gas (GHG) in diverse ways Bălteanu*et al*., 2013.

The maincauses of increasing CO_2 associated to land use have been the alteration of natural vegetation, shrub, and wetlands to farming land and settlements, which has been aggravated by road creation and other substructures.Considerate the position of LULC is energetic for the assortment and the potentials for ideal use of land-use kinds to encounter the growinganxieties for rudimentary human needs in agreement with ecological protection Rawat and Kumar, 2015. A mixture of crop and farming trees in agroforestry land-use type typically provides to alleviate climate alteration and bringinnumerable outcomes in ecological, economic, and social servicesJarzebskiandGasparatos, 2019.

Aggregate is a basic unit of soil structure, and it is an intermediate form of single grained and massive structures, aggregates as a naturally occurring cluster or group of primary particles stabilized by cementing materials like organic matter, iron and aluminum oxides, carbonate and/or silica. The formation and maintenance of stable aggregate is essential feature of soil tilth and they are more sensitive to land use management practices Six *et al*. 2004. Distribution and stability of soil aggregate are the key indicator of soil quality and physical health of soil as it reflects the conditions of many physical properties viz. bulk density, porosity, water retention and release behavior, air and temperature movement in soils, erosivity of soil and can facilitate many chemical and biological processes in soilCavalieri *et al*., 2009; Saree *et al*., 2012.The stability and distribution of different size aggregates [coarse macro-aggregate (> 2.0 mm), meso-aggregate (2.0 - 0.25 mm) and micro-aggregate (< 0.25 mm)] is greatly influenced by land-use practices and soil depth Shrestha, 2004.Mean weight diameter (MWD) of soil aggregates is the most widely used index for size distribution of stable aggregates in soil and an important indicator of soil heath as it directly affects different physical, chemical and biological properties of soil and greatly influenced by changes in land use practices and soil depth Celik, 2005; Gajic *et al.*, 2006.

Distribution and stability of soil aggregates is determined by the quality and quantity of associated carbon fractions Jastrow *et al*., 1998. Soil organic carbon plays an important role in the formation and stabilization of soil aggregates Spohn and Giani., 2011. There exists a close relationship between soil aggregation and soil organic carbon accumulation because SOC directly promotes soil aggregation through its binding action. The extent of carbon retention in soil depends on the nature of aggregation. Carbon sequestration in soil could be enhanced through promotion of aggregation and amount of organic carbon fractions associated with different size soil aggregates. This might be an effective strategy to mitigate the increasing concentration of atmospheric CO_2 through judicious land use management practices Bajracharya*et al*., 1998;Bronick and Lal, 2005.

Material and Methods

Study area

The existing study was carried out during 2019 under different land use practices (forest land, perennial fodder land, uncultivated land, wheat-soybean cropping system, rice-wheat cropping system, mango orchard, citrus orchard, guava orchard and aonla orchard) at horticultural research farms of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The experimental site is situated at 23^{0}10' N latitude, 79^{0}57' E longitudes and at elevation 393.0 meter above mean sea level in theSouth-Eastern part of the Madhya Pradesh and central India. The sites of forest land, uncultivated land and different orchards were more than fifteen years old, while fields of perennial forage, soybean-wheat and rice-wheat cropping systems in same practice from last ten years. Soil of the study sites were swell-shrink typevertisols havingdark greyish brown to dark yellowish-brown colour belongs to *Kheri* series of fine Montmorillonite hyperthermic family of T*ypic Haplustert* and known as medium black soil.The climate in the Jabalpur is generally nice and respectable. The tropic of cancer passes through the middle of the district. It has sub-tropical climate characterized by hot dry summers and cool winters. Jabalpur lies in the "*Kymore* Plateau and *Satpura* hills" agro-climatic zone of Madhya Pradesh. The average maximum temperatures during the month of June-July varies between 41.8 to 44.4 ^{0}C and are the hottest month of the year, while the average minimum temperature ranges from 5.4 to 9.3 ^{0}C during December-January, which are the coldest month of the year. The average annual rainfall over the district is 1276 mm which is mostly received between June to September (summer monsoon) and a little rainfall (74 to 176 mm) received during October to May. The average humidity of the region is about 74 per cent and average evaporation is 3.94 mm day^{-1}.

Table 1: Experimental details and treatments:

Main plot treatments (Land use practices)	:	L_1: Forest land L_2: Perennial forage land L_3: Uncultivated land L_4:Aonla orchard L_5: Rice-Wheat system L_6: Soybean-Wheat system L_7: Guava orchard L_8: Mango orchard L_9: Citrus orchard
Sub-plot treatments (Soil depths)	:	D_1: 0-20 cm D_2: 20-40 cm D_3: 40-60 cm
Replications	:	03
Design of Study	:	Split plot design
Number of samples	:	81 (09 x 03 x 03)

Collection of soil samples

Soil samples were collected in three replicates from selected sites in different land uses (forest, perennial forage, uncultivated, soybean-wheat, rice-wheat, mango orchard, citrus orchard, guava orchard and aonla orchard) at 0-20, 20-40 and 40-60 cm depths using post hole auger sampler.After taking the sample from different sites in a land use plan the composite sample is prepared for the different the depths separately by using the quartering method. The composite sample is used for the analysis of different aggregates thoroughly using the sieve method. The study,focus on different soil aggregates and mean weight diameter. The detail accounts of methodologies followed during course of present study are described under following sub-heads:

Determination of aggregate size distribution:

The wet sieving technique as prescribed in modified Yoder's sieving method (Yoder, 1936) was used for aggregate size analysis. Composite soil samples collected at 0-20, 20-40, and 40-60 cm from each land uses were brought to the laboratory and air dried then broken gently with cleavage. Samples were cleaned by removing roots, lime concretion, larger stone *etc*. For aggregate size analysis 200 g of air-dried clod passed through 8.0 mm sieve and retained on 5.0 mm sieve were taken. Entire (200 g) soil sample was placed on the top (5.0 mm sieve) of the sieve set (5.0, 2.0, 1.0, 0.5, 0.25, 0.1 mm) from top to bottom. Spread the soil samples (200g) evenly in top sieve (5.0 mm) and 10-15 ml of salt free water was sprayed on soil and after 5 minutes another 5 ml of water have been sprayed. Then sieve set was transferred to the drum of sieve shaker and clamped in position. Drum was filled with salt free water up to a level slightly below the top sieve keeping it in highest position. On the oscillator switch and let the sieve oscillate in water for 10 minutes with a frequency of 30 cycles per minutes through a stroke length of about 3.8 cm. Sieves set was too out of drum and drain of water was allowed then sieves were separated and placed on paper sheet and aggregate retained on each sieve were allowed to dry and harden in air. Amount of soil material retained on each sieve was dried in an oven at 105 ^{0}C for 24 hours and proportion of each size fraction of soil aggregates in percentage was computed.

Determination of mean weight diameter of soil aggregate

Mean weight diameter of soil aggregate is commonly used index of soil structure. It gives an estimate of weighted percentage of average size of all aggregates. The mean diameter of any particular size range of aggregates (X_i) is multiplied by the weight of the aggregates in that size range as a fraction of total dry weight of sample analysed (W_i). The sum of the products gives the MWD in mm.

$$\mathrm{MWD} = \sum_{i=1}^{n} \mathrm{XiWi}$$

Where,

Xi is mean diameter of ith size fraction in mm; n is number of size ranges and Wi is the weight of aggregates of size fraction**.**

Statistical analysis

The data pertaining to each character of the soil were tabulated and analysed statistically by applying the standard technique analysis of variance for split plots design was worked out in MS excel sheet and the significance of treatments were tested to draw valid conclusion as described by Gomez and Gomez, 1984. The differences of treatments mean were tested by 'F' test of significance on the basis of null hypothesis. Critical differences were worked out at 5 percent level of probability where 'F' test was significant. If the variance ratios (F-test) were found significant at 5% level of significance, the standard error of mean (SEm±) and critical differences (CD) were calculated accordingly.

Result and discussion

Results obtained during the present study have enumerated in different points. The results of the study obtained and analysis carried out to determine the distribution of different size soil aggregates and mean weight diameter of aggregates in relation to contrast land use practices (forest, uncultivated and perennial fodder lands; soybean-wheat and rice-wheat systems; mango, citrus, guava and aonla orchards) and soil depths (0-20, 20-40, and 40-60 cm) are presented under following heads:

Effect of land use practices and soil depth on distribution of different size soil aggregate:

Data pertaining to effect of land use practices and soil depths on distribution of different size soil aggregate are presented in table 2. It is evident from the data that distribution of different size aggregate fractions (> 5.0, 2.0-5.0, 1.0-2.0, 0.5-1.0, 0.25-0.5, 0.1-0.25 and < 0.1 mm) were significantly affected by land use practices and soil depths but the interaction effect of land use practices and soil depths on distribution of different size aggregate fractions have been found non-significant. Bandyopadhyay*et al*., 2010; Choudhary *et al*., 2010reported that land use strongly influences the soil properties like distribution and stability of aggregates due to change in types of vegetation, frequency and intensity of tillage, use of organic matter and depth of soil.

Data revealed that proportion of soil aggregates having size > 5.0 mm was highest (9.4 %) under forest land which have been significantly superior over those obtained under perennial fodder land (7.4%), aonla orchard (6.7%), rice-wheat system (4.4%), soybean-wheat system (4.3%), guava orchard (7.5%), mango orchard (7.6%) and citrus orchard (6.7%) but statistically at par with uncultivated land (9.0%). Whereas, proportion of > 5.0 mm size soil aggregates under perennial fodder land, aonla, guava, mango and citrus orchards were statistically on par but found significantly superior over those obtained under rice-wheat and soybean-wheat systems which were statistically at par. Data also showed that amount of > 5.0 mm size soil aggregates decreased significantly with successive increase in soil depth and highest (8.5%) value was found at 0-20 cm depth and lowest (5.4 %) at 40-60 cm depth.The results are found similarly byNascente*et al.*, 2015; Lawal *et al.*, 2009and reported that fractions of macro-aggregates were significantly higher in forest land as compared to cultivated land and proportions of micro-aggregates increased with soil depth irrespective of land use practices.

Data further showed that proportion of soil aggregates having size 5.0-2.0, 2.0-1.0 and 1.0-0.5 mm were highest (17.0, 21.7 and 18.1%) under forest land which had been statistically on par with those obtained in uncultivated land (15.5, 21.6 and 18.1%), respectively and significantly superior over those found under perennial fodder land (15.0, 20.9 and 16.9%), aonla orchard (13.6, 18.4 and 17.7%), rice-wheat system (9.3, 15.1 and 16.2%), soybean-wheat system (8.5, 15.4 and 16.3%), guava orchard (13.1 18.5 and 14.4%), mango orchard (12.6, 18.9 and 15.3%) and citrus orchard (11.7, 17.2 and 16.5%) respectively. Data also indicated that proportion of soil aggregates having size 5.0-2.0, 2.0-1.0 and 1.0-0.5 mm were decreased significantly at successive depth increases, with highest (15.2, 21.6 and 20.3 %), respectively at 0-20 cm depth and lowest at 40-60 cm depth. The similar findings was reported by Shrestha and Lal (2008) and found that water-stable macro-aggregates (>2 mm) in forest and pasture land soils were 24, 90 and 66%, and 13, 74 and 43% higher than arable land at 0-5, 5-15, and 15-30 cm depths, respectively.

Data presented in table 2 also revealed that proportions of 0.5-0.25 and 0.25-0.10mm size aggregate fractions were maximum (21.8 and 20.0%) under rice-wheat system which had been statistically at par with those under soybean-wheat system (21.5 and 20.0 %) but significantly higher over those found under forest land (12.1 and 11.9%), perennial fodder land (13.4 and 13.7%), uncultivated land (11.9 and 12.1%), aonla orchard (15.2 and 16.0 %), guava orchard (14.6 and 13.6%), mango orchard (15.1 and 13.7%) and citrus orchard (15.0 and 15.3%), respectively. It was also noticed that proportions of 0.5-0.25- and 0.25-0.10-mm size aggregates increased significantly with consecutive increase in soil depths and found highest (19.2 and 20.1 %) at 40-60 cm depth, respectively. The similar findings also reported by Manna *et al*., 2007 macro-aggregates having size range of 0.25 to 2 mm were dominant (43–61%) in surface (0–15 cm soil. And also reported by Gebremariam and Kebede, 2010 stated that WSA in surface soils of the three land uses ranged from 46.86 to 52.55% with highest in forest land and lowest in farmland.

Table2: Effect of land uses and soil depth on distribution of different size soil aggregates

Treatments	**Distribution of different size soil aggregates (%)**						
Land use practices (Main plots)	**> 5.0 mm**	**2.0-5.0 mm**	**1.0-2.0 mm**	**0.5-1.0 mm**	**0.25-0.5 mm**	**0.10-0.25 mm**	**< 0.10 mm**
L_1: Forest land	9.4	17.0	21.7	18.1	12.1	11.9	9.8
L_2: Perennial forage land	7.4	15.0	20.9	16.9	13.4	13.7	12.7
L_3: Uncultivated land	9.0	15.5	21.6	18.1	11.9	12.1	11.7
L_4: Aonla orchard	6.7	13.6	18.4	17.7	15.2	16.0	12.4
L_5: Rice-Wheat system	4.4	9.3	15.1	16.2	21.8	20.3	12.8
L_6: Soybean-Wheat system	4.3	8.5	15.4	16.3	21.5	20.0	14.0
L_7: Guava orchard	7.5	13.1	18.5	14.4	14.6	13.6	18.2
L_8: Mango orchard	7.6	12.6	18.9	15.3	15.1	13.7	16.9
L_9: Citrus orchard	6.7	11.7	17.2	16.5	15.0	15.3	17.6
SEm ±	**0.28**	**0.53**	**0.54**	**0.42**	**0.49**	**0.41**	**0.21**
CD (*p=0.05*)	**0.81**	**1.55**	**1.56**	**1.23**	**1.45**	**1.19**	**0.56**

Soil Depth (Sub-plots)							
D_1 0-20 cm	8.5	15.2	21.6	20.3	10.6	8.2	15.7
$D_2$20-40 cm	7.0	14.0	17.5	17.1	17.1	17.2	10.0
$D_3$40-60 cm	5.4	9.6	16.9	12.5	19.2	20.1	16.3
SEm ±	**0.13**	**0.22**	**0.31**	**0.38**	**0.24**	**0.26**	**0.15**
CD (*p=0.05*)	**0.35**	**0.62**	**0.86**	**1.09**	**0.66**	**0.72**	**0.43**
Interaction (M x S)							
SEm ±	**0.37**	**0.67**	**0.98**	**1.13**	**0.96**	**0.89**	**0.44**
CD (*p=0.05*)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.28**

Data further revealed that proportion of soil aggregates of size < 0.10 mm was significantly affected by different land use practices and soil depths. It was maximum (18.2%) under guava orchard followed by citrus orchard (17.6%) and mango orchard (16.9%), while minimum (9.8%) in forest land followed by uncultivated land (11.7%). Data clearly indicated that proportion of soil aggregates of size < 0.10 mm was significantly affected by soil depths with highest (16.3%) at 40-60 cm followed by 0-20 cm (15.7%) and lowest (10.0%) at 20-40 cm depth. The similar findings were reported by Kalhoro*et al*., 2017.

Effect of land use practices and soil depths on mean weightdiameter of soil aggregates:

Mean weight diameter (MWD) of soil aggregates is an important indicator of soil quality in terms of movement of nutrients, water, air and temperature in soil which ultimately regulates the root growth. The data pertaining to effect of land use practices and soil depth on MWD of soil aggregates are presented in table 3. It is clearly evident from the data that MWD of soil aggregates was significantly affected by land use practices and soil depth and their interaction as well.

Data clearly showed that among the land uses practices largest (1.30 mm) MWD of soil aggregates was found under forest land followed by uncultivated land (1.24 mm) and perennial forage land (1.13 mm) while smallest (0.78 mm) MWD have been obtained under soybean–wheat system followed by rice–wheat system (0.80 mm). The similar findings were reported by

Debasish *et al.,* 2011 also suggested that mean weight diameter of soil aggregates was significantly higher in forest land over the cultivated soil. And the results might be due to extent of soil disturbances. Data also revealed that MWD of soil aggregates under forest and uncultivated lands were statistically on par but significantly superior over those found in other land uses. Similarly, MWD of soil aggregates under aonla, guava and mango orchards were statistically at par but significantly superior over those obtained under rice-wheat and soybean-wheat systems and citrus orchard. And also, similar findings reported by Arnab *et al*., 2012 and states that higher amount of WSA of size >2 mm in grassland (95.7%) and lowest in agriculture (50.5%) and eroded land (40.1%) at 0-15 cm soil depth.Data also revealed that (MWD) of soil aggregates significantly decreased with increase in soil depth and it was highest (1.20 mm) at 0-20 cm depth followed by 1.09 mm (20-40 cm) and smallest (0.83 mm) at 40-0 cm depth. The similar findings also reported by Somasundaram *et al*., 2012;Emadi et al., 2009. Interaction effect of land use practices and soil depths on mean weight diameter of soil aggregates was also found significant. MWD of soil aggregates under forest land at 0-20 cm (1.53 mm), 20-40 cm (1.33 mm) and 40-60 cm (1.04 mm) depths were statistically at par with those found under uncultivated land but significantly higher than the other land uses at respective depths**.**The similar findings were reported byKubar*et al*., 2018; Nascente*et al*., 2015. And also reported by Gajic *et al*., 2006 and states that higher amount of macro-aggregate and larger MWD in forest soil and micro-aggregates (< 0.25) and smaller MWD in cultivated soil at 0-20 cm soil depth.

Table 3: Effect of land use practices and soil depths on mean weight diameter of soil aggregates

Treatments	**Mean weight diameter of soil aggregates (mm)**									
Land uses / Soil Depth(cm)	**FLL$_1$**	**PF L$_2$**	**UL L$_3$**	**AO L$_4$**	**RW L$_5$**	**SW L$_6$**	**GO L$_7$**	**MO L$_8$**	**CO L$_9$**	**Mean**
D$_1$ (0-20 cm)	1.53	1.36	1.43	1.23	0.94	0.84	1.16	1.16	1.10	**1.20**
D$_2$ (20-40 cm)	1.33	1.15	1.26	1.13	0.86	0.85	1.10	1.09	1.08	**1.09**
D$_3$ (40-60 cm)	1.04	0.87	1.02	0.79	0.61	0.64	0.91	0.86	0.74	**0.83**

Mean	**1.30**	**1.13**	**1.24**	**1.05**	**0.80**	**0.78**	**1.06**	**1.04**	**0.97**	**1.04**
Comparison of main plot (Land use practices) treatments									**SEm ±**	**0.024**
									CD (p=0.05)	**0.069**
Comparison of sub-plot (Soil depth) treatments									**SEm ±**	**0.010**
									CD (p=0.05)	**0.027**
Comparison of main plots at the same level of sub-plot treatments									**SEm ±**	**0.029**
									CD (p=0.05)	**0.082**
Comparison of sub-plot at the same or different levels of main treatments									**SEm ±**	**0.022**
									CD (p=0.05)	**0.062**

Note: Forest land (FL), perennial forage (PF), Uncultivated land (UL), Aonla orchard (AO), Rice-wheat (RW), Soybean-Wheat (SW), Guava Orchard (GO), Mango Orchard (MO), Citrus Orchard (CO).

Conclusion: The present study investigated those macro-aggregates (> 0.50 mm size) were higher under undisturbed lands (forest, uncultivated and perennial forage), followed by least disturbed (orchard land) and lowest under crop land (rice-wheat and soybean-wheat systems), whereas, amount of micro-aggregate (< 0.50 mm size) fractions increased with soil depth and macro-aggregates were maximum at 0-20 cm depth. Mean weight diameter of soil aggregates was significantly affected by land use practices and soil depths with highest under forest land and lowest in soybean-wheat system. And also, the mean weight diameter of soil aggregates was decreased with increase in soil depth. The soybean-wheat cropping system is better than the rice-wheat cropping system. The forest land is better than all the cropping systems.

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