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RESEARCH PAPER

Erodibility status of soils under different land uses in Longleng district soils of Nagaland

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Abstract : Land use effect on soil erodibility parameters were studied in four villages, *viz.*, Tamlu village, Tamlu town, Kangching and Namsang in Longleng district, Nagaland, under four land uses, *viz.*, *Jhum*, lowland rice, forest and orange in each village. The mean textural class of the soils were clay and clay loam. Dispersion ratio and erosion index were recorded to be usually higher than the threshold limits. Dispersion ratio of the soils ranged from 11.08 to 71.83 where as, erosion index varied between 17.94 and 78.02. A significant and negative correlation of clay with dispersion ratio and erosion index was observed. The highly significant and positive correlation between erosion index and dispersion ratio indicated the susceptibility of these soils to water erosion. Proper agronomic and mechanical soil and water conservation measures need to be adopted to protect the soils from further degradation

Key Words : Land uses, Dispersion ratio, Erosion index

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INTRODUCTION

Land use changes affect many natural resources and ecological processes such as surface runoff and erosion and changes soil resilience to environmental impacts. The increasing intensity of land use may cause erosion and soil compaction through changes in soil physical and chemical properties. Unsuitable changes in land use due to human activities are a widespread problem that leads to land degradation. Soil structure and soil physical properties can be influenced by different land management operations. Land use changes from natural ecosystems into managed ecosystems resulted in negative impact on soil structure and quality (Rasheed, 2016). Environmental degradation caused by unsuitable land use is a worldwide problem that has revitalized the issue of sustainability (Mandal *et al.*, 2010). Soil erosion is a significant economic and environmental problem worldwide as a driving force affecting landscapes. One of the main causes of soil loss intensification around the world is associated with land-use change. Soil erosion depends on the erosivity of the rainfall and the erodibility of soil. The erodibility depends primarily on the physical characteristics of the soil, *viz.*, nature and amount of soil aggregates, organic matter and particle size distribution. Physico-chemical properties and different land uses are

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important determinants of the magnitude of erosion. Intensive land use caused much alteration in the soil physico-chemical properties. The physical properties of a soil play an important role in determining its suitability for crop production. Soil protection is fundamental so as to maintain soil services and avoid land degradation. The assessment of erosion hazard can be quantified by different erosion indices of soil such as dispersion ratio and erosion index. The information pertaining to erodibility of soils of Longleng district of Nagaland is very limited. Keeping this in view, the present investigation was undertaken to evaluate the erodibility status of soils under different land uses in the region. Attempt was also made to find out the correlation among the erodibility indices as well as with mechanical composition of soil to identify the important soil properties affecting the erodibility of soils.

MATERIAL AND METHODS

Soil samples from 0-15 and 15-30 cm depth were collected from four different land uses, *viz.*, *Jhum*, lowland rice, forest and orange cultivation from four different locations around Tamlu sub division, the sub headquarters of Longleng district *viz.*, Tamlu village, Tamlu town, Kangching and Namsang. Longleng is located between longitude 94°E - 95°E and latitude 26°'N - 27°N of the Equator. It has an average elevation of 1066 metres above mean sea level. The climate of the study area is temperate to sub-tropical with mean annual temperature of 16ºC. The average annual rainfall ranges from 1800 mm to 2500 mm. These collected soil samples were air dried and processed and analysed for particle-size distribution following International Pipette method (Piper, 1966) using 0.5 N NaOH as a dispersing agent. The water holding capacity was determined using Keen Rackzowaski boxes as described by Baruah and Barthakur (1997). Suspension percentage (water dispersible silt + clay) was determined by dispersing 25g soil in 1000 ml distilled water without adding any dispersing agent, shaking end over end for 20 times and pipetting out 20 ml of soil suspension from 10 cm depth as suggested by Middleton (1930). The erodibility indices *i.e.* dispersion ratio and erosion index were computed using the procedures described by Middleton (1930) and Sahi *et al.* (1977), respectively as follows:

$$\text{Dispersion ratio} = \frac{\%\ \text{water dispersed (Silt + clay)}}{\%\ \text{(Silt + clay) particle size analysis}}$$

$$\text{Erosion index} = \frac{\text{Dispersion ratio}}{\text{Clay/0.5 water holding capacity}}$$

The statistical analysis of the data was done as per procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads:

Mechanical composition of soil:

The sand content of surface and sub-surface soils in the different villages under various land uses ranged from 28.18 to 46.82% and 26.68 to 44.47%, respectively (Table 1). The highest sand was recorded in surface soil of Tamlu village under *Jhum* while the lowest was in sub surface soils of Namsang village under orange land use. The silt content in the surface soils, irrespective of village and land use ranged from 10.21 to 26.86% whereas, in sub-surface soils it varied from 14.80 to 27.23% (Table 1). The maximum silt was found in sub surface soil of Namsang village under orange land use while the minimum was recorded in surface soil of Tamlu village under low land rice cultivation. The clay in the surface and sub-surface soils in different villages under various land uses ranged from 32.71 to 50.13% and 32.82 to 50.12%, respectively. The highest clay was found in surface soil of Tamlu village under low land rice, while the lowest was in surface soil of Tamlu village under *Jhum* cultivation.

The textures of the surface soils in various land uses under different villages were recorded as sandy clay loam, clay loam and clay. The textures of sub-surface soils were either clay or clay loam. The mean textural class of 0-15 cm soils under *Jhum*, low land rice and orange land use was clay whereas, mean textural class under forest land use was clay loam. The mean textural classes 15-30 cm soil under of *Jhum* and orange land use was clay loam whereas, mean textural class under low land rice and forest land use was clay. Diengdoh *et al.* (2016); Goswami and Challa (2006); Laxminarayana (2010), Singh and Dutta (1989) and Sharma *et al.* (2012) also reported similar results for the soils of North Eastern Hill region.

Dispersion ratio:

The dispersion ratio of the top soils under *Jhum*, low land rice, forest and orange land uses varied from 35.86 to 59.81, 19.72 to 50.03, 26.89 to 71.83 and 33.16

to 60.43 with an average of 44.44, 34.96, 48.01 and 49.46, respectively (Table 2). The highest mean dispersion ratio in surface layer was found in Kangching soils followed by Tamlu town, Tamlu village, and Namsang soils. The dispersion ratio of the sub surface soils under *Jhum*, low land rice, forest and orange land uses ranged from 27.01 to 48.92, 11.08 to 41.81, 26.12 to 45.20 and 21.95 to 52.81 with an average of 36.10, 28.00, 37.91 and 38.65, respectively. The highest mean dispersion ratio in 15-30 cm soil layer was found in Kangching soils followed by Tamlu town, Namsang, and Tamlu village soils. Considering upper limit of dispersion ratio as 15 suggested for non-erosive soil by Middleton (1930), all the soils are susceptible to erosion except sub-surface soils of Tamlu town under low land rice land use. Aggregation, which may be due to clay and organic carbon content, leads to structural stability of soil resulting in low soil loss and soil erodibility values (Singh and Khera, 2006).

Dispersion ratio of <5, 6-10, 11-15, 16-25, 26-30 and >30 were categorized as very stable, stable, fairly stable, somewhat unstable, unstable and very unstable. Out of 32 soils, 25 were found to be very unstable, 4 unstable, 2 somewhat unstable and 1 come under fairly stable. The dispersion ratio of sub-surface soils of Tamlu town under low land rice was fairly stable, whereas, surface soils of Tamlu town under low land rice and sub-surface soils of Namsang under orange land use were recorded as somewhat unstable. On the other hand dispersion ratio in surface and sub-surface soils of forest and sub-surface soils of *Jhum* in Tamlu village and sub-surface soils under low land rice of Namsang were found as unstable. The dispersion ratio in rest of the soils was observed as very unstable. Kahlon (2006) also found lower values of erosion ratio and dispersion ratio for the soil of forest and grasslands than those of arable and bare lands. In 10 out of 16 soil profile, dispersion ratio was higher in surface soils than in sub-surface soils which might be attributed to higher content of clay and soil aggregation in the lower depth. Similar observation was also reported by Diengdoh *et al.* (2016); Mehta *et al.*

Table 1: Textural class of soils under various land uses

Land use and location	Sand %		Silt %		Clay %		Textural class	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Jhum								
Tamlu village	46.82	38.10	19.47	20.18	32.71	40.72	Sandy Clay loam	Clay
Tamlu town	39.70	40.30	18.47	21.09	40.83	37.61	Clay	Clay loam
Kangching	37.17	39.80	22.32	16.97	39.01	42.03	Clay loam	Clay
Namsang	36.83	40.43	18.97	25.45	43.20	32.82	Clay	Clay loam
Mean	40.13	39.66	19.81	20.92	38.94	38.29	Clay	Clay loam
Low land								
Tamlu village	38.06	29.23	10.21	21.64	50.13	48.13	Clay	Clay
Tamlu town	31.80	36.15	17.82	17.83	49.18	44.82	Clay	Clay
Kangching	28.18	30.70	29.08	21.06	40.64	47.14	Clay	Clay
Namsang	35.60	29.88	26.86	20.21	36.54	48.91	Clay loam	Clay
Mean	33.41	31.49	20.99	20.18	44.12	47.25	Clay	Clay
Forest								
Tamlu village	45.20	31.66	16.07	16.72	37.60	50.12	Sandy clay	Clay
Tamlu town	42.08	28.37	17.81	21.43	39.81	38.90	Clay loam	Clay loam
Kangching	35.89	32.47	22.43	17.42	40.68	48.71	Clay	Clay
Namsang	42.56	34.89	20.75	22.17	35.69	41.74	Clay loam	Clay
Mean	40.93	34.85	19.77	19.44	39.23	44.87	Clay loam	Clay
Orange								
Tamlu village	39.24	44.47	17.84	14.80	41.72	38.63	Clay	Clay loam
Tamlu town	41.61	43.51	19.41	18.91	37.98	36.49	Clay loam	Clay loam
Kangching	36.06	39.54	22.63	20.74	40.31	37.82	Clay	Clay loam
Namsang	31.21	26.68	24.18	27.23	44.20	42.09	Clay	Clay
Mean	37.02	38.55	21.02	20.42	41.05	38.76	Clay	Clay loam
Average	37.87	36.14	20.40	20.24	40.84	42.29	Clay	Clay

(2005), Singh *et al.* (2006) and Sharma and Kumar (2010). The dispersion ratio and erosion index of forest soil was lower as compared to bare soil (Khera and Kahlon, 2005). Kumar and Singh (2007) also reported lower dispersion ratio in forest land use as compared to orchard and cultivated land use.

Erosion index:

The erosion index of the top soils under *Jhum*, low land rice, forest and orange land uses ranged from 45.90 to 76.31, 24.17 to 66.66, 35.67 to 58.66 and 34.80 to 78.02 with an average of 59.38, 50.71, 46.66 and 59.82, respectively (Table 3). The maximum mean erosion index in surface soil was recorded in Kangching soils followed by Tamlu town, Namsang, and Tamlu village soils. The erosion index of the sub surface soils under *Jhum*, low land rice, forest and orange land uses varied from 29.83 to 47.81, 17.94 to 43.07, 28.46 to 47.14 and 29.97 to 47.54 with an average of 39.52, 33.89, 33.73 and 41.56, respectively. The highest mean erosion index in sub-surface soil was recorded in Tamlu village soils followed by Kangching, Tamlu town and Namsang soils. Considering upper limit of dispersion ratio as 15 suggested for non-erosive soil by Middleton (1930), all the soils are susceptible to erosion except sub-surface soils of Tamlu town under low land rice land use. Considering 2.8 as threshold value of erosion index (Sahi *et al.*, 1977), all the soils under study were recognized as erodible class and need conservation measures on priority to prevent them from getting further degradation. Comparatively higher erosion index in surface layers suggested that soils under all the land uses are more susceptible to sheet and rill erosion. Similar observation was also reported by Diengdoh *et al.* (2016) for the soils of North Eastern hill region. Saha *et al*. (2011) from a soil erodibility characteristics study under modified land-use systems at Umiam, Meghalaya reported that *Jhum* cultivation showed the highest erosion ratio, followed by agriculture, indicating the need to adopt tree-based land-use systems for resource conservation.

Erosion index of 0-5, 6-10, 11-15, 16-20 and >20 were categorized as very low, low, medium, high and

Table 2 : Dispersion ratio of soils under various land uses

Villages	Soil depth (cm)	Land use				
		Jhum	Lowland	Forest	Orange	Mean
Tamlu village	0-15	44.27	39.86	26.89	44.12	38.78
	15-30	27.01	32.13	26.12	30.85	29.02
Tamlu town	0-15	37.80	19.72	42.18	60.43	40.03
	15-30	36.40	11.08	36.25	52.81	34.13
Kangching	0-15	59.81	50.03	71.83	60.13	60.45
	15-30	48.92	41.81	44.07	48.97	45.94
Namsang	0-15	35.86	30.21	51.14	33.16	37.59
	15-30	32.08	26.98	45.20	21.95	31.55
Mean	0-15	44.44	34.96	48.01	49.46	
	15-30	36.10	28.00	37.91	38.65	

Table 3: Erosion index of the soils under various land uses

Villages	Soil depth (cm)	Land use				
		Jhum	Lowland	Forest	Orange	Mean
Tamlu village	0-15	54.03	51.83	35.67	54.26	48.94
	15-30	47.81	43.07	30.14	45.92	41.73
Tamlu town	0-15	45.90	24.17	58.66	78.02	51.68
	15-30	39.18	17.94	47.14	42.81	36.76
Kangching	0-15	76.31	66.66	50.16	72.21	66.33
	15-30	41.24	39.83	29.19	47.54	39.45
Namsang	0-15	61.29	60.17	42.16	34.80	49.60
	15-30	29.83	34.71	28.46	29.97	30.74
Mean	0-15	59.38	50.71	46.66	59.82	
	15-30	39.52	33.89	33.73	41.56	

Table 4 : Co-efficient of correlation between erodibility parameters and soil separates

Soil properties	Dispersion ratio	Erosion index
Erosion index	0.64**	
Sand	0.20	0.22
Silt + Clay	-0.18	-0.23
Clay	-0.33*	-0.35*

*and ** indicate significance of values at P=0.05 and P=0.01, respectively

very high. Out of 32 soils, all soils fall under very high erosion index, except the soils of low rand rice of Tamlu town which falls under high erosion index. These results are in the line with the findings of Singh and Kundu (2008), Kumar and Singh (2007) and Sharma and Kumar (2010). Yilmaz *et al*. (2007) found that at cultivated and forested sites, the erosion index and dispersion ratio increased with increasing soil depth. Diengdoh *et al.* (2016) also reported lower erosion index for forest soils as compared to *Jhum* and other cultivated land uses.

Relationship among dispersion ratio, erosion index and soil properties:

The correlation co-efficient values revealed that clay and silt+clay had negative correlation with dispersion ratio and erosion index (Table 4). The positive correlation of sand with dispersion ratio and erosion index revealed that the presence of higher amount of sand increased the erodibility of soil as it increased the dispersion ratio and erosion index. As the dispersion ratio increased, erosion index also increased indicating greater susceptibility of these soils to water erosion. The highly significant correlation between erosion index and dispersion ratio was also reported by Kumar and Singh (2007); Agnihotri *et al*. (2007) and Diengdoh *et al.* (2016). The significant negative correlation of dispersion ratio and erosion index with clay suggested that soil erodibility decreased with increase in clay content. Rasheed (2016); Sharma and Kumar (2010) and Singh and Kundu (2008) also reported similar results. It can be concluded that all the soil under study are highly susceptible to water erosion. Therefore, proper soil and water conservation measures either biological or mechanical need to be adopted to protect these soils from further degradation.

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