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SOIL AND ORGANIC MATTER CHARACTERIZATION OF AN AGARIAN MICRO WATERSHED IN CHOTANAGPUR HIGHLANDS

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ABSTRACT

Livelihood across Chotanagpur highlands primarily depends on subsistence farming. Fertility of soil is of utmost importance to the tribal population. Thus, necessary knowledge of soil characteristics is crucial for sustainable development and overall welfare of the region. The Jumar Nala micro watershed was chosen for the study. Soil samples were collected at three depths (0-15, 15-30 and 30-60 cms) and analyzed for different parameters. The soil textures varied from sandy clay loam to clay loam, had low organic carbon and were acidic in nature. The soil of the region needs pH amendments in order to increase the availability of the nutrient pool. A change in the agricultural practices is also advisable in order to increase the organic carbon content.

KEYWORDS : Soil characterization, Chotanagpur Highlands

Soil is that invaluable, diverse, and fragile natural resource at Earth's terrestrial surface that provides for life support. Soil may be defined as the unconsolidated mineral material on the immediate surface of the earth that has been subjected to and influenced by genetic and environmental factors. (Knox, 1965). Research shows that conventional agriculture has accelerated soil erosion to rates that exceed that of soil formation (Montgomery, 2007). Soil erosion in the last 40 years has led to 30% of the world's arable land to become unproductive and, much of that has been abandoned for agricultural use (Kendall and Pimentel, 1994; WRI, 1994). Thus, making it important to conserve soil and reduce the rates of soil erosion.

Soil characterization in relation to evaluation of fertility status of the soils of an area is an important aspect in context of sustainable agricultural production, and soil-water conservation. Knowledge of spatial variability of field soils, with respect to their physical properties is an important aspect of watershed management. Though number of research work on physical characterization of soil has been conducted in India and abroad (Arshad and Coen, 1992; Carter, 1996; Pan et al., 2012), most of these works were confined for a specific type of soil under a specific land situation. The complete information to describe the physical properties of soil of the selected micro watershed has not been done so far.

Determination of Different Parameters For Soil Characterization

Texture

It refers to the size of the particles that make up the soil. The terms sand, silt, and clay refer to relative sizes of the soil particles. Sand, being the larger size of particles, feels gritty. Silt, being moderate in size, has a smooth or floury texture. Clay, being the smaller size of particles, feels sticky. Texture plays an important role on availability of soil moisture.

Bulk Density

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed in g/cm^3. It is dependent on soil texture (sand, silt, and clay) and organic matter content.

Soil Reactivity or pH

It often referred to as the master variable of soil, controls a wide range of physical, chemical, and biological processes and properties that affect soil fertility and plant growth. Soil reactivity (pH) greatly influences the nutrients available for plants. With the exception of P, which is most available within a pH range of 6 to 7, macronutrients (N, K, Ca, Mg, and S) are more available within a pH range of 6.5 to 8, while the majority of micronutrients (B, Cu, Fe, Mn, Ni, and Zn) are more available within a pH range of 5 to 7 (Brady and Weil 2008). Soil pH is measured to assess

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potential nutrient deficiencies, crop suitability, and pH amendment needs.

Organic Carbon

Organic carbon constitutes 50% of organic matter. It is defined as the summation of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and well-decomposed substances (Brady and Weil, 1999).

Infiltration Characteristic

Infiltration characteristic of the soil is one of the most important hydrological parameter that governs the run-off generation. The infiltration rate of a soil depends on factors that are constant, such as the soil texture, and on factors that vary, such as the soil moisture content. It also depends on the type of crop, due to the effects of the rooting system.

MATERIALS AND METHODS

The selected micro watershed (Upper Subarnarekha Jumar Nala micro watershed: 4H3C8a3c) lies in the state capital of Jharkhand, Ranchi. The selected area extends from $23^0$26'30"-$23^0$30'10" North latitude to $85^0$18'20"-$85^0$20'15" East longitude. It covers the Kanke block of the district and has seven villages in it. The watershed receives an average annual rainfall of 1500 mm. Entire area of the Jumar Nala watershed is a blend of different land situations. Soil surface varies from being flat to being sloppy, undulating and rolling in topography. The direction of the slope of the land is towards South-east. The average slope varies from 1 to 5%. The cultivated lands have been classified into upland, medium land and low land for convenience in distinction from each other. It is mainly based on visual observation of elevation and slope. Most of the land in the watershed is mono-cropped (generally paddy) except those situated near the river/stream or having irrigation facilities, where wheat is grown successfully in rabi season. Vegetable cultivation, generally cucurbits, cauliflower and cabbage are done by the progressive farmers of the region. Few fruit orchards are also present. Maize cultivation is seen in low land areas.

Collection of Soil Samples For Site Characterization

The parent soil samples were collected before the first rainfall event of the monsoon season of 2010. The watershed was divided into five classes (upland left (UL), upland right (UR), medium land left (ML), medium land right (MR) and lowland (LL)). Soil samples from each class were collected at three different locations with the help of hand auger at 3 depths (0-15 cm, 15-30 cm and 30-60 cm). All together there were 45 parent soil samples as detailed below:

Number of classes: 5

Sampling location in each class: 3

Soil depth at each location: 3

Total number of samples (5*3*3): 45

Soil samples were air dried and analyzed for texture, bulk density, soil reactivity (pH), electrical conductivity, organic carbon and macronutrients using standard laboratory methods (Dhyan et al., 2005).

RESULTS AND DISCUSSION

Texture

In general, the soils of all the classes were found to be light to medium in texture varying between sandy clay loam at the surface and clay loam at the 30-60 cm soil depth with some variation in silt and clay content along the depth of soil profile (Table, 1). Considering the variation in texture at different depths, it was observed that LL, ML and MR had almost similar composition, having a common texture of clay loam from 0 to 60 cm. However, mapping units UR and UL had slightly lighter texture (sandy clay loam) in the 0-60 cm layer.

The clay content was found to increase down the depth of the profile (varying from 22.4% at the surface to as high as 31.0% in the lower horizons) in all the classes, probably because of translocation of finer particles under the influence of high intensity rainfall of the area with relatively less compacted soils at the surface.

Bulk Density

The bulk density of the soil in different classes ranged between 1.29 and 1.49 g cm^3 in different soil layers (Table, 2). A general trend of decrease in the values of bulk density down the depth from about 1.46 g cm^3 in the 0-15 cm layer to about 1.35 g cm^{-3} in the 30-60 cm layer was observed, indicating thereby a subsequent decrease in compactness of the soil with increase in soil depth. This may be attributed to an increasing trend of clay content down the depth of the soil (Table, 2). The depth wise variation of bulk density in different classes though didn't differ markedly, but an overall picture indicates that the bulk density of the soil varied in the order LL < ML < MR < UR < UL, the latter two UR and UL' being closer to each other. However, the bulk density of soil of all classes is in the favorable range of farming (Arshad et al., 1996) and is conducive to normal root distribution of crop plants.

Soil Reactivity (pH)

The upland soils were more acidic with respect to the lowland soils. Soil reactivity varied from 6.44 to 4.79. Amongst these, the surface soils had higher pH across the soil profile for all classes. The higher acidity in the surface layer may be attributed to the loss of considerable amount of organic content along with the high intensity rainfall through surface/subsurface run-off. The pH values also followed the trend of variation in the order, LL > ML > MR > UR > UL, supporting the reasons of higher acidity in soils of upland than those of lowland.

Table 1: Soil Texture

Classes	Depth	Sand	Silt	Clay	Textural Class
LL	0-15	47.4	25.4	27.2	S C L
	15-30	40.6	29.8	29.6	C L
	30-60	37.6	31.4	31	C L
	W A	**42.4**	**28.6**	**29**	**C L**
ML	0-15	47.6	25.4	27	S C L
	15-30	42.4	28.6	29	C L
	30-60	38.6	30.8	30.6	C L
	W A	**43.4**	**27.9**	**28.7**	**C L**
MR	0-15	48.8	25.4	25.8	S C L
	15-30	43.2	28	28.8	C L
	30-60	40	30.4	29.6	C L
	W A	**44.5**	**27.6**	**27.9**	**C L**
UR	0-15	54.4	23.2	22.4	S C L
	15-30	46.4	26	27.6	S C L
	30-60	44	27.6	28.4	C L
	W A	**48.8**	**25.3**	**25.9**	**S C L**
UL	0-15	50.4	24.2	25.4	S C L
	15-30	45.4	26.2	28.4	C L
	30-60	41.2	29.4	29.4	C L
	W A	**46.2**	**26.2**	**27.6**	**S C L**

SCL= Sandy Clay Loam
CL= Clay Loam
WA= Weighted Average

Table 2: Physical Properties

Depth (cm)	Bulk density (g/cm3)	Organic Carbon (%)	pH
LL			
0-15	1.42	0.54	6.3
15-30	1.37	0.39	6.37
30-60	1.29	0.29	6.65
W A	**1.36**	**0.42**	**6.41**
ML			
0-15	1.43	0.53	5.9
15-30	1.38	0.37	6.15
30-60	1.32	0.27	6.39
W A	**1.38**	**0.4**	**6.11**
MR			
0-15	1.46	0.41	5.7
15-30	1.39	0.36	6.2
30-60	1.34	0.26	6.3
W A	**1.4**	**0.39**	**6.03**
UR			
0-15	1.49	0.46	5.44
15-30	1.41	0.33	6.1
30-60	1.36	0.24	6.22
W A	**1.42**	**0.35**	**6.88**
UL			
0-15	1.47	0.48	5.73
15-30	1.4	0.34	6.15
30-60	1.35	0.25	6.27
W A	**1.41**	**0.37**	**6.02**

Organic Carbon/ Organic Matter Content

Organic carbon content was found to gradually decrease down the depth of soil (Table, 2). The values ranged between 0.54% in the surface layer and as low as 0.24% in the 30-60 cm layer. Decreasing trend of organic carbon down the depth of the soil is a well established fact as the organic matter content, normally becomes highest in the surface layer contributed by the residues of flora and fauna, which gradually decreases down the depth of the soil. The soils of different classes showed a tread of variation in the following order LL > ML > MR > UR > UL with respect to organic matter content. Classes UR and UL were at the higher elevation as compared to the rest where elevation decreased gradually to the mapping unit LL. Lower organic carbon content in the uplands could also be a result of comparatively lower clay content and erosion. The eroded soil from the upper portions of the slope might have been deposited in the soils of lower slopes thereby increasing the organic matter content of the soils in medium land and lowland areas.

Infiltration Rate

The Infiltration rate decreased from 22.8 to 2.2 cm/hr in LL, 26.4 to 3.0 cm/hr in MR, 30.0 to 3.2 cm/hr in ML, 33.6 to 3.4 cm/hr in UL and 37.2 to 3.9 cm/hr in UR, from the initial measurement at 5 minutes up to 200 minutes. At 200th minute and onwards up to the end the figures of infiltration rate remained firmly stable at 2.2, 3.0, 3.2, 3.9 and 3.4 cm/hr for LL, MR, ML, UR and UL soils, respectively and following the trend of variation in the order LL < ML < MR < UL < UR. The gradual decrease with time may be attributed to the swelling of clay and dispersion of finer particles which might have gradually narrowed down the pore diameter, resulting in gradual lowering of infiltration rate.

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