STUDIES ON THE STRUCTURAL STABILITY OF SOME SOILS OF WEST BENGAL

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(Communicated by S. P. Raychaudhuri, F.N.A.)

(Received 28 August 1973)

This paper presents information on the structural stability of some major soils of West Bengal. Four representative soils of West Bengal were collected from Nadia, Birbhum, 24 Paragnas and Darjeeling districts of West Bengal. Status of aggregation in four soils reveals that the extent of aggregation varies considerably in different soils. The order of increase in structural stability is presented as Brown forest soil > Lateritic soil > Alluvial soil > Saline alkali soil. Various factors affecting structural stability have also been studied.

One of the explicit factors that governs soil erosion is the role of hydraulic cycle in soil profile which has been given enough expression in the work of Harton (1933). The capacity of soil to absorb water and moderately rapid transmission of water through the profile are of paramount importance in the study of soil erosion (Lutz 1934; Tamboli *et al.* 1965). Importance of porosity characteristics of aggregation is well brought out by the work of Tamboli *et al.* (1965) on water retention, root distribution by Edwards *et al.* (1964) and nutrient availability by Wiersum (1962). Thus role of soil structure in the hydrologic cycle and its bearing on the erodability need not be overemphasized. Experimental studies reported here are directed to have an insight into the factors that affect structural stability and status of aggregation in some soils of West Bengal.

EXPERIMENTAL

Reconnaissance studies were conducted in different soil regions presenting varying geology, topography, soil and vegetation. Four representative profiles occurring under varied conditions were selected. The profile sites were confined to (*i*) Gangetic alluvium, (*ii*) Lateritic, and (*iii*) Saline-alkali and Brown forest soils (Fig. 1). The rainfall characteristics are furnished below :

Soil type	District	Annual rainfall (cm)
Alluvial	Nadia	139 — 165
Lateritic	Birbhum	104 — 139
Saline-alkali	24 Parganas	134 — 170
Brown forest soil	Darjeeling	228 — 254

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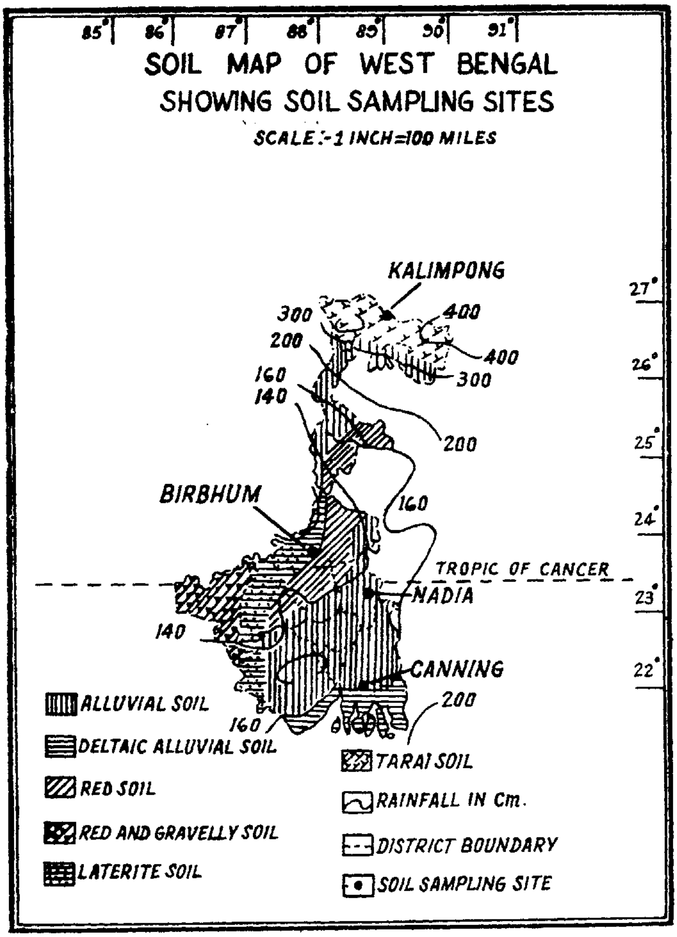

FIG. 1. Map showing soil sampling sites.

The tropic of cancer runs across the middle of the district Nadia and Burdwan. The portion lying north of this line is in the north temperate zone and the southern portion within the equatorial zone. Though the southern portion lies within the equatorial zone the presence of Bay of Bengal and the Gangetic river system keeps the climate under control. The proximity of mountain range increases the rainfall rate in the northern part of the State.

The greater part of the plains of West Bengal is covered with alluvium. Lateritic soil is noticed from Orissa in the north and spreads out to the districts of Midnapur, Burdwan and Birbhum of West Bengal flanked by the hills of Rajmahal. Saline-alkali soils are of tidal origin. The original deltaic branches of the Ganges river got choked up because the head-water had been cut off as a result of which numerous tidal flats have been formed. Brown forest soils are found at an altitude of about 600 metres and the active soil formation can be seen up to 2400 metres altitude. The genesis of the well foliated type passing into mica schist constitutes the greater

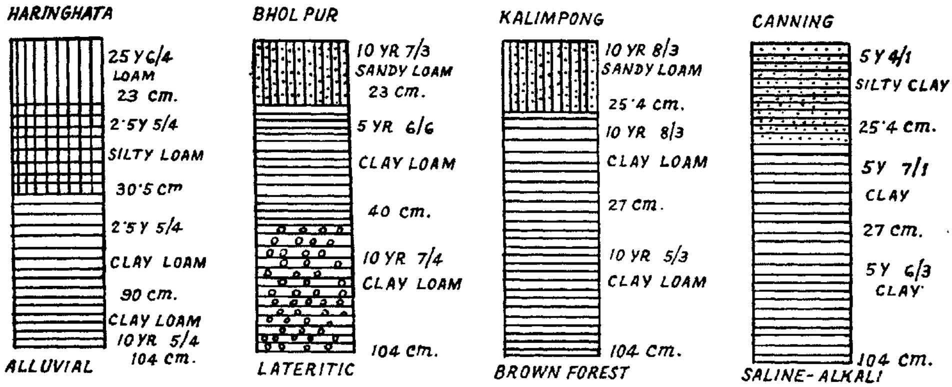

FIG. 2. Different profiles to illustrate horizon description of soils under investigation.

portion of the Darjeeling Himalayas. Details regarding the selected profiles are presented in Fig. 2.

Physico-chemical properties of different soils can be seen in Tables I and II. Surface soil samples were subjected to wet sieving following the procedure described by Yoder (1936) to estimate the structural stability of each soil type. Mechanical analysis of soil samples of different aggregate sizes was done by International pipette method (Piper 1950). Plasticity index and sticky points were also estimated as per method described by Piper. Organic carbon was estimated by the method of Walkley and Black Nitrogen was estimated by modified Kjeldahl method (Piper 1950). *p*H was electrometrically measured by photovolt *p*H meter in 1:1.5 soil water suspension. Cation exchange capacity was determined by ammonium acetate method described by Piper (1950). Aluminium and iron oxide were determined by Fusion analysis suggested by Jackson (1958). After separating sesquioxide, calcium was precipitated as oxalate at *p*H 4.5 (calcium oxalate method) as described by Jackson (1958).

Results and Discussion

Mean percentage of total water stable aggregates of four soils presented in Table III reveals that the extent of aggregation varies considerably in different soils. An attempt to correlate aggregate formation with soil forming climatic factor and temperature brings out the following. The order of increase of rainfall in different soils can be presented as brown forest soil > saline-alkali soil > alluvial soil > lateritic soil, whereas structural stability represented by aggregate percentage is brown forest soil > lateritic soil > alluvial soil > saline-alkali soil. The change in the order may be due to the influence of temperature and other concomitant effects associated with it. Brown forest soil possesses the highest aggregation percentage as it should be in the light of the rainfall data. High rate of rainfall is often associated with increased amounts of clay content. Analytical data show that clay content is low among all soil types. From the heavier texture of the B horizon it may be inferred that high rate of rainfall causes eluviation of clay content from A to lower horizon. Though low temperature adversely effect clay formation

TABLE I

Physical properties of four different soils under study
(in percentage on oven dry basis)

Constituent	Soil types			
	Alluvial	Lateritic	Forest	Saline
Coarse sand %	2.20	36.50	30.02	—
Fine sand %	31.06	32.30	32.00	10.48
Silt %	40.00	15.48	20.20	43.30
Clay %	24.20	15.50	15.00	45.60
Loss on solution %	2.00	0.003	0.03	0.51
Organic matter	0.54	0.19	2.75	0.11

TABLE II

Chemical composition of four soils

Soil type	*p*H	CEC/meq 100 g	C %	N %	Fe_2O_3 %	Al_2O_3 %	R_2O_3 %	CaO %	Air dry moisture
Alluvial	6.21	21.2	0.31	0.33	3.92	5.8	9.98	0.54	2.02
Lateritic	5.8	11.0	0.11	0.015	5.32	5.94	11.30	0.25	1.5
Brown forest	6.2	31.6	1.6	0.17	6.45	8.30	16.65	0.39	3.1
Salline-alkali	8.5	12.1	0.06	0.065	4.32	5.21	13.1	0.45	1.61

TABLE III

Mean percentage of tota water stable aggregates of four soils

Soil type	Upper limits of different aggregate sizes					Total aggregates (%)
	0.25	0.5	1.0	2.0	5.0	0.1 (mm)
Alluvial	17.167	10.954	11.718	10.513	16.841	67.193
Lateritic	23.672	15.646	17.430	9.626	4.746	71.120
Brown forest	7.445	8.207	9.879	14.812	34.266	74.609
Saline-alkali	3.316	0.417	0.166	0.156	—	4.055

organic matter content has been recorded very high. This is vividly brought out in Table II. Observation of Jenny Hans (1930) is in line with the findings of the results of the present study.

In the case of lateritic soil there is an abrupt shift. According to rainfall data lateritic tract falls under the lowest order but aggregation status is in the

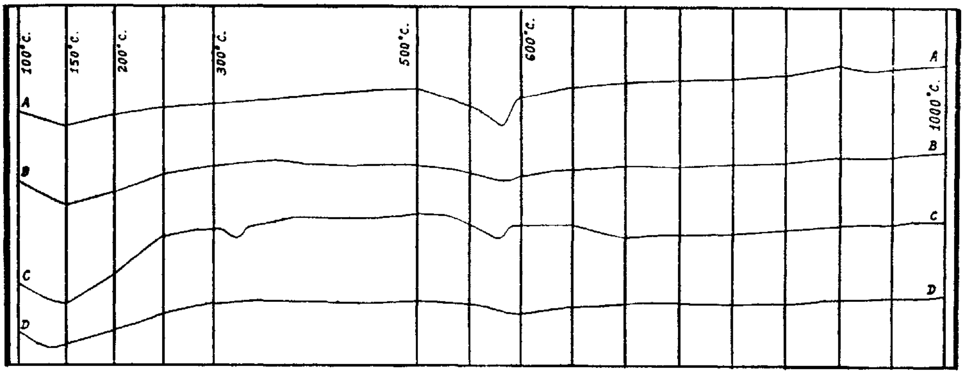

FIG. 3. Differential thermal curves of four different soils under investigation. A, Lateritic; B, Alluvial; *C*, Brown forest soil; D, Saline alkali soil.

second place next to brown forest soil. Lateritic soil does not exhibit any sign of correlation between aggregation and organic matter, which possesses a very low organic matter content. Though there can be multiplicity of factors that cause aggregation, Table II indicates the predominence of Fe_2O_3 which in turn gives rise to irreversible colloids and produces stable aggregates in lateritic soil. It has been observed that iron is precipitated as hydrated gel and provides firm adhesiveness to floculated particles.

Saline alkali soils, though fall under second place in the rate of rainfall, aggregation status is lowest. This may be explained in view of the high rate of sodium and potassium present in the soil which inhibits the aggregation of silt and clay fractions. Geoghegan's (1959) experimental results furnish satisfactory evidence to show the inefficacy of organic matter over aggregation of sodium soils. The poor status of aggregation of sodium soils is further established by the work of Richard *et al.* (1948).

Alluvial soil exhibits good relationship between rainfall and aggregation both having placed in the third place. Table II presents the percentage of calcium content as the highest and organic matter in the second place. Keeper as quoted by Wirsum (1962) maintains that liming does not always affect the physical properties of soil. Yoder (1936) also came across the same type of result. But it may be inferred from the findings of the results of both calcium and organic matter that calcium could exert influence on the organic matter to enhance microbial activity which in turn produces better aggregation. Besides, higher percentage of finer fractions of silt and clay may also be considered as important factors that goes to form satisfactory status of aggregation.

Results of the distribution of different aggregate size groups indicate that the highest amount of water stable aggregates fall within the range 0.1 to 0.25 mm.

The abnormal increase of brown forest soil in its percentage of aggregation can possibly be explained by the following reasons : Partially weathered fragments of parent material are seen embeded within the aggregates of higher order (about 21 per cent by weight). Binding action of roots is found to be profuse in this zone.

TABLE IV

Mean weight diameter limits of separation, frequency weight, accumulated frequency weight of four soils under investigation

Soil type	Limit of separation (mm)	Frequency weight (%)	Accumulated frequency weight (%)	Mean weight diameter (cm)
Alluvial (Nadia Dist.)	0–0.1	32.807	32.807	
	0.1–0.25	17.167	49.974	
	0.25–0.5	10.954	60.928	
	0.5–1.0	11.718	72.646	
	1.0–2.0	10.513	83.159	
	2.0–5.0	16.841	100.00	0.0439
Lateritic (Birbhum Dist)	0–0.1	28.880	28.880	
	0.1–0.25	23.672	52.552	
	0.25–0.5	15.644	68.198	
	0.5–1.0	17.430	85.628	
	1.0–2.0	9.626	95.254	
	2.0–5.0	4.746	100.00	0.0212
Brown forest soil (Darjeeling Dist.)	0–0.1	25.391	25.391	
	0.1–0.25	7.445	32.896	
	0.25–0.5	8.207	41.043	
	0.5–1.0	9.879	50.922	
	0.0–2.0	14.812	65.734	
	2.0–5.0	34.266	100.00	0.0734
Saline-alkali (24-Parganas)	0–0.1	95.945	95.945	
	0.1–0.25	3.316	99.261	
	0.25–0.5	0.417	99.678	
	0.5–1.0	0.166	99.844	
	0.0–2.0	0.156	—	
	2.0–5.0	—	100.00	0.0011

It is generally observed that all the four soils except saline-alkali are characterised by better water stable aggregate. Status of *p*H did not show any favourable corre-ation with aggregation.

Cation exchange capacity on aggregation too did not show any favourable trend. This may be due to diversified factors effecting soil structure. But evidence can be seen of its relative effect with status of aggregation in brown forest and alluvial soil.

Sensitive measurements such as mean weight diameter, frequency weight, accumulated frequency weight of four soils are presented in Table IV which indicate wide variation in the soil structure of different soils.

An attempt was made to find out the effect of clay mineral on soil aggregation by differential thermal analysis. The thermogram for clay minerals of different soils presented in Fig. 3 gives a clear picture of this aspect. The presence of clay mineral kaolinite, montomorillonite and illite in different soils have not shown significant effect on the degree of aggregation due to various other factors responsible for aggregation discussed above.

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