NEWTON'S COOLING COEFFICIENTS OF U.P. SOIL CLAYS IN WATER MEDIA

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The Newton's cooling coefficients (N.C.C.) of twelve soil clays of U.P. in aqueous media show that the values for the same soil-climatic regions are almost the same for the three different soil clay water ratios used although the values differ with the different soil-climatic regions. Soil clays of semi-desert and semi-arid regions recorded high N.C.C. values than the soil clays of humid and sub-humid regions. The higher values of N.C.C. of the soil clays of semi-desert regions are among other factors, due to the presence of illite and montmorillonite.

Introduction

Soil clay is generally colloidal in nature and their presence in soils is, therefore, of outstanding importance in relation to their physical, chemical and biological behaviour. Along with humus, it is an active ingredient of the soil because of its grea, specific surface, a property, which is not associated with sand and silt.

A number of useful properties of soil clays have been reported in the literature (Grim 1968; Marshall 1964; Rich and Kunze 1964; and Black 1965) but reports are not available on the study of Newton's cooling coefficient of soil clays in aqueous system. De and Shukla (1967, 1968) and Shukla, Lal and De (1973) observed earlier the Newton's cooling coefficient values (k) of pure clay minerals in normal solutions of NH_4Cl, NaCl and KCl and in non-aqueous media nitrobenzene, carbon tetrachloride and isoamyl alcohol for the identification of different clay minerals. The other thermal properties of soil clays show that they have some minor relation not only with the different physico-chemical properties of soils but also with the clays themselves (Baver 1962).

In this paper, an attempt has, therefore, been made to observe, how far, the Newton's cooling coefficients of the soil clays obtained from the twelve representative soils of U. P. are related to their constituents and to the different soil-climatic regions to which they belong.

Experimental

The different soil samples collected by the accepted methods were analysed in the laboratory for their important physico-chemical properties (Piper 1947). Separation of the clay fraction from these soils was done by the method advocated by Puri (1935). The clay fractions were chemically analysed for the more important of their constituents (Piper 1947; De 1965). The clay samples were subjected to X-ray, IR and DTA analyses for the determination of their predominant clay minerals (Grim 1968).

Newton's cooling coefficients (k) of soil clays were determined by the method reported earlier by De and Shukla (1967). The k values were determined in clay-water systems with clay to water ratios, 1:100, 2:100 and 4:100. The k values were calculated from the simple relation,

$$k = \frac{2.303}{t} \log_{10} \frac{20}{(\theta - \theta_0)}$$

where, θ_0 = temperature of the surroundings (30°C); θ = temperature of the medium and t = time.

Results and Discussion

The Newton's cooling coefficient values of the twelve soil clays in aqueous media have been reported in Table I. The average Newton's cooling coefficient values of the soil clays belonging to different soil-climatic regions have been given in Table II. It may be observed that the Newton's cooling coefficient values of the soil clays vary according to the soil-climatic regions and also with the ratio of soil clay to water. In Table III, it may be observed that the Newton's cooling coefficient values of soil clays belonging to the semi-desert regions are higher than the soil clays belonging to sub-humid or humid regions. The values for the soil clays of the semi-arid and arid regions are almost intermediate. It was earlier concluded (De, Tripathi, Pandey and Singh 1973) that the soils with a high Newton's cooling coefficient value ($>$25.0 min^{-1}) in aqueous media are comparatively less important agriculturally in that they do not support a wide range of crops than the soils of the other regions, which record lower Newton's cooling coefficient values. The intermediate values of the clays of semi-arid and arid soils support again our previous contention and show their importance in the field of agriculture in the state of U.P.

In addition, the Newton's cooling coefficient values of almost all the soil clays, are on the lower side of the value 25.0 (De *et al.* 1973) which indicates their great importance in the contribution of soil fertility and productivity.

It is generally known that a soil clay containing purely one kind of clay mineral will not be as useful as the one that contains a suitable proportion of the three important types of clay minerals viz., montmorillonite, illite and kaolinite. The predominant clay minerals found in the different soil clays by X-ray, DTA and IR-methods are shown in Table II. According to De and Shukla (1967, 1968) the Newton's cooling coefficient values of the three important clay minerals in aqueous media will lie between the approximate values 19.0 to 22.0. The values shown in Table II support the idea of De and Shukla (1967, 1968). According to them an illitic clay will have a higher Newton's cooling coefficient value than a montmorillonite clay and the value of montmorillonite clay will be slightly higher than that of a kaolinitic clay. This is in support of the findings of Jenny and Reitmeir (1935) and Jenny (1938) who observed that the dispersion of a particle will be dependent upon its saturating cations and the resulting zeta potential of the particles. Higher the hydrates of the saturating cation, greater will be the dispersion and zeta potential of the particles. Illite is known to have potassium as an important cation, montmorillonite having divalents like calcium and magnesium and kaolinite having

TABLE I

Physico-chemical composition of the soil clays

Soil-clays	Soil-climatic region	SiO_2 (%)	R_2O_3 (%)	Fe_2O_3 (%)	Al_2O_3 (%)	CaO (%)	MgO (%)	K_2O (%)	*p*H	B. E. C.
Agra	Semi-desert	44.80	18.02	4.00	14.02	1.00	0.63	0.47	5.60	32.50
Aligarh		39.72	15.44	4.64	10.80	1.16	0.62	1.31	7.50	23.00
Allahabad	Arid	44.81	19.92	8.00	11.92	0.80	0.44	1.50	7.20	39.00
Lucknow		41.60	15.94	6.32	9.62	0.34	0.76	0.68	4.50	22.00
Jhansi		41.90	16.82	5.20	11.62	1.56	0.98	0.68	6.20	56.00
Jaunpur	Semi-arid	40.52	16.32	5.92	10.40	1.40	0.82	1.41	6.50	19.00
Bareilly		39.60	20.72	9.36	11.36	0.92	0.46	0.60	7.70	41.00
Gorakhpur	Sub-humid	38.40	23.44	9.76	13.68	1.46	1.00	0.78	5.40	20.50
Nainital		35.35	20.42	6.24	14.18	3.14	1.16	0.93	8.60	26.50
Dehradun		48.00	16.22	5.68	10.54	0.76	0.67	0.86	4.00	29.00
Tehri-Garhwal	Humid	48.38	20.20	7.12	13.08	1.02	0.98	0.51	7.00	16.00
Mussoorie		51.66	19.82	7.36	12.46	0.52	0.96	1.37	5.70	28.50

TABLE II

Newton's cooling coefficients (K) of U.P. soil-clays in aqueous media

Soil-climatic Regions of U.P.	Soil-clays	Predominant clay minerals	$K^* = (k/n \times 10^3)\ min^{-1}$ 1:100	2:100	4:100
Semi-desert	Agra	IMK	25.47	24.63	25.15
	Aligarh	IK	23.02	22.58	22.57
	Allahabad	KM	22.88	22.02	20.30
Arid	Lucknow	K	24.55	25.00	24.00
	Jhansi	MKI	21.30	21.05	20.82
	Jaunpur	K	26.40	25.75	25.00
Semi-arid	Bareilly	KM	21.44	20.09	19.90
	Gorakhpur	KM	22.95	22.83	21.63
Sub-humid	Nainital	KI	19.16	19.10	19.00
	Dehradun	KM	19.60	19.40	19.28
	Tehri-Garhwal	IK	21.84	21.63	21.57
Humid	Mussoorie	KI	20.08	19.97	19.71

TABLE III

Newton's cooling coefficients of soil clays of different soil-climatic regions of U.P. in water

Soil-climatic region of U.P.	Predominent clay minerals	Newton's cooling coefficients $(k/n \times 10^3)min^{-1}$ 1:100	2:100	4:100
Semi-desert	IMK	24.24	23.60	23.86
Arid	KMI	22.91	22.70	21.71
Semi-arid	MK	23.92	22.92	22.45
Sub-humid	KMI	20.84	20.44	20.00
Humid	KI	20.46	20.80	20.64

M=Montmorillonite; I=Illite; K=Kaolinite.
*K is the Newton's cooling coefficient.

trivalents like aluminium; K^+ is known to have greater hydration than Ca^{++} and calcium greater than the trivalent Al^{+++}. The zeta potential in the case of illitic clays will, therefore, be higher than the montmorillonitic clays and this in turn will be greater than the kaolinitic clays. According to De *et al.* (1973) an aqueous system having particles of clay or soils of high zeta potential will record higher

TABLE IV

Order of Newton's cooling coefficients of soil clays of different soil-climatic regions of U.P. in water

Soil:Water	Order
1:100	Semi-desert > Semi-arid > Arid > Sub-humid Humid
2:100	Semi-desert > Semi-arid > Arid > Humid Sub-humid
4:100	Semi-desert > Semi-arid > Arid > Humid Sub-humid

Newton's cooling coefficient values than similar systems having soils or clay particles of lower zeta potential. Since the predominant clay minerals of the soil clays as reported in Tables II and III are not of one type for any particular soil clay or soil climatic regions, the corresponding results of the Newton's cooling coefficients will depend on the proportions of each of the clay minerals observed in the soil clays. It is by now definite that a soil clay having a preponderance of kaolinitic clay minerals will record a lower Newton's cooling coefficient value in aqueous media than a soil clay having either illite or montomorillonite. Similarly, higher proportion of illite in the soil clays will mean a higher Newton's cooling coefficient in aqueous media than the soil clays having either montmorillonite or kaolinite. The higher Newton's cooling coefficient values in the soil clays of semi-desert region may, therefore, be due to the presence of illite as the predominant clay mineral.

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