MINERALOGY OF THE LAYER SILICATES IN WEST PAKISTAN SOILS

GHULAM SARWAR AND INAMUL HAQ*

SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratio of less than two micron fraction of soil ranged from 3.23 to 4.85 and 2.46 to 3.33 respectively. The total K_2O content varied from 2.89 to 4.11 per cent indicating that mica (illite) content of these soils was fairly high.

The correlation coefficient for the relation of specific planer surface to cation exchange capacity of clay fraction was 0.98 which is highly significant. The correlation coefficient for the relation of specific planer surface to per cent mica (illite) content was −0.95 indicating that specific surface increases with the decrease in the mica content.

The mica (illite) and quartz plus feldspare content of clay fraction varied from 29 to 41 and 3 to 61 per cent respectively. The montmorillonite plus vermiculite content of the samples was generally low ranging from 0 to 37 per cent, although 5 of the samples had montmorillonite plus vermiculite content above 25 per cent.

From the content of clay minerals it could be roughly concluded that illite content increased from East to South-West while the montmorillonite plus vermiculite content decreased. The content of quartz plus feldspars showed a trend similar to illite. This tendency in the variation of clay minerals was not found to be consistent as many exceptions were noticed. The variation in clay minerals was not found to be correlated with the soils deposited by different rivers.

INTRODUCTION

The term clay has been given to the less than two micron fraction of soil. Clay minerals are intimately associated with such soil properties as soil reaction, adsorption power, nutrient fixation, dispersion, flocculation shrinkage, swelling, aggregation and the permeability of soil to air and water. The

*Department of Soil Science, Faculty of Agriculture, University of Agriculture, Lyallpur.

magnitude of these properties is dependent on the type and amount of clay minerals present. The mineralogical information is also desirable in problems related to soil formation and classification. Thus this knowledge is indispensible to the soil chemist as well as to the agronomist for an understanding of the physico-chemical properties of soil and its reaction to various management practices. For an efficient and productive use of soils, an understanding of their mineralogical nature is very essential. This paper furnishes this information about West Pakistan Soils.

REVIEW OF LITERATURE

Kanwar (1959, 1969) reported that soils from Amritsar Ludhiana, Ferozepur and Karnal had SiO_2/R_2O_3 ratio of 2 to 3. These colloids were found to contain about 75 per cent of illite as the clay mineral, with some chlorite which is a Mg-bearing clay mineral with properties similar to illite.

Dogar (1962) concluded that minerals dominantly present in the clay colloids from West Pakistan were illite, and montmorillonite. The montmorillonite content decreased from Peshawar to Sind, whereas the illite content increased.

McNeal (1966) reported that clay minerals present in the less than two micron fraction of Punjab soils were dominated by the presence of mica, chlorite, quartz plus feldspars and montmorillonite. He concluded that for the clay samples from Punjab, either cation exchange capacity or surface area measurement could be used to provide an approximate mineralogical estimate.

MATERIAL AND METHODS

A number of methods are available for mineralogical studies of soil. X-ray diffraction, differential thermal analysis and electron microscope yield more accurate and reliable information. Because of the paucity of facilites, this investigation had to be restricted to such physical and chemical estimations which were considered to be of importance for throwing some light on the mineralogy of our soils. The chemical analysis, cation exchange capacity and specific surface determination of less than two micron fraction of soils from different soil series in Sialkot, Lahore, Gujrat, Jhelum, Gujranwala, Sargodha, Lyallpur and Jhang were made after the removal of soluble salts organic matter and free sesquioxides. These soils represent the alluvial deposites from Sutlej, Ravi, Chenab and Jhelum rivers.

RESULTS AND DISCUSSION

A. Molecular Ratios and Cation Exchange Capicity.

Data presented in Table 1 indicate that both SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios of less than two micron fraction of soil are quite high ranging from 3.23 to 4.85 and 2.46 to 3.33 respectively. The study of the pure samples of clay have shown that SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios for 2 : 1 type of layer lattice are generally higher than 1 : 1 layer lattice (Hendricks and Alexander, 1939). The total non-exchangeable K_2O varied from 2.89 to 4.11 per cent which indicated that mica (illite) contents of these soils were fairly high. The cation exchange capacity of less than two micron fraction varied from 12.4 me to 51.5 me/100 g. The maximum value of cation exchange capacity (51.5 me/100 g) with minimum value of K_2O (2.89 per cent) was observed in case of sample from Kotli series (Sialkot).

B. Specific Surface.

The maximum value of specific planer surface (331 m_2/g.) was observed in case of sample from Kotli series (Sialkot) and the minimum value of 48m_2.

TABLE 1: *Estimation of minerals present in less than two Micron Fraction of twenty West Pakistan Soil Samples*

Soil Series	Depth (cm)	SiO_2/Al_2O_3	SiO_2/R_2O_3	K_2O %	CEC me/100 g	SPS m_2/g
Miani	22—45	3.46	2.61	3.66	19.6	111
Khurrianwala	15 – 40	3.41	2.67	4.11	12.4	48
Lyallpur	22—55	3.32	2.53	4.04	14.5	79
Jaranwala	20—45	3.55	2.53	4.10	13.8	66
Gujranwala	20—50	4.54	3.06	3.31	36.9	255
Miani	25—50	3.71	2.70	3.74	18.8	113
Gujranwala piedment plain	30—50	3 92	2.95	3.47	27.5	199
Miani	25—50	3.69	2.79	3.55	23.2	128
Gujranwala	25—50	4.43	3.04	3.01	47.8	309
Bhalwal	30—50	3.26	2.46	3.68	16.6	91
Gujranwala	30—50	3.38	2.59	3.86	17.4	104
Eminabad	15—40	4.15	3.11	3.25	42.0	269
Hafazabad	25—50	3.23	2.79	3.86	15 9	101
Kotli	25—50	4.85	3.33	2.89	51.5	331
Kamokie	15—30	4.03	2.94	3.19	46.4	302
Bhalwal	20—50	3.35	2.65	3.92	15.9	104
Kasur	41—51	3.59	2.60	3.98	15.2	83
Rustam	25—50	3.78	2.96	3.49	26.8	150
Feroz eroded	15—30	3.40	2.58	3.74	16.7	99
Joanna	25—50	3.86	2.92	3.40	30.4	163

was found in the less than two micron fraction of Khurrianwala series (Lyallpur), with an average value of 155 m_2/g for the twenty soil samples studied. A precise specific surface determination is a unique analytical tool for analysis of the contents of montmorillonite and vermiculite of soils and sediments (Mehra and Jackson, 1959). The correlation coefficient for the relation of specific planer surface to cation exchange capacity of the less than two micron fraction of soil was 0.98 which is highly significant. Such important properties as water retention and cation exchange capacity have been shown to be highly correlated with the surface area of soil (Mortland and Kemper, 1965).

C. Clay Minerals.

An approximate estimate of the clay mineral composition of less than two micron fraction of soils under study was made by the use of total K content, specific planar surface and cation exchange capacity of the clay fraction. An assumed value of 8.3 per cent K in soil mica (illite) was used (Jackson, 1956; McNeal and Sansoterra, 1964). After calculating the approximate percentage of mica, the specific surface attributable to the mica content was found out by taking 150m^2 /g as its specific surface (McNeal, 1966). The difference in the total specific surface of the particular soil colloid and that of the calculated amount of mica was used for the estimation of montmorillonite plus vermiculite by the use of following equation as suggested and used by Mehra and Jackson (1959).

$$\% \text{ (Mt. + Vr.)} = \frac{\text{Specific planar surface, } m^2./g. \text{ (by difference)}}{\text{Thearetical planar surface (808 to 760 } m^2./g.)}$$

Cation exchange capacity of the less than two micron fraction of soil was used for the estimation of quartz plus feldspare present as suggested by Mc Neal (1966).

Data presented in Table 2 show that mica (illite) content varied from 29 to 41 per cent. The content of less than two micron fraction quartz plus feldspare ranged from 3 to 61 percens, with about half the samples containing at least 50 percent. The montmorillonite plus vermiculite content of the samples was generally low ranging from 0 to 37 per cent, with 5 samples containing above 25 per cent. The correlation coefficient for the relation of specific planar surface to per cent mica (illite) was –0.95, indicating that specific surface increase with the progressive weathering of micas. Specific surface measurement is one quantitative measure of the decrease in mcia content with weathering because it increases with a decrease in K content (Jackson, 1956).

SUMMARY AND CONCLUSIONS

SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios of less than two micron fraction of soil ranged from 3.23 to 4.85 and 2.46 to 3.33 respectively. The total K_2O content varied from 2.89 to 4.11 per cent indicating that mica (illite) content of these soils was fairly high.

The correlation for the relation of specific planar surface to cation exchange capacity of clay fraction was 0.98 which is higoly significant. The correlation coefficient for the relation of specific planar surface to per cent mica (illite) content was -0.95 indicating that specific surface increases with the decrease in the mica content.

TABLE 2. *Approximate Mineral Composion of less than two Micron Fraction from twenty West Pakistan Soils.*

No.	Soil Series	Depth (cm)	Mica (illite)	Montmorillonite plus vermiculite	Quartz plus feldspars
1.	Miani	22—45	37	7	49
2.	Khurrianwala	15—40	—	—	61
3.	Lyallpur	25—55	40	2	56
4.	Jaranwala	20—45	41	—	57
5.	Gujranwala	20—50	33	27	24
6.	Miania	25—50	37	7	50
7.	Bhalwal	30—50	37	5	53
8.	Gujranwala piedment plain	30—50	35	19	38
9.	Miani	25—50	36	9	44
10.	Gujranwala	25—50	30	34	8
11.	Gujranwala	30—50	38	6	52
12.	Eminabad	15—40	33	28	17
13.	Hafizabad	25—50	38	6	54
14.	Kotli	25—60	29	37	3
15.	Kamokie	15—30	32	33	10
16.	Bhalwala	20—50	39	7	54
17.	Kasur	41—51	40	3	55
18.	Rustam	25—50	35	11	38
19.	Feroz eroded	15—30	37	6	53
20.	Joanna	25—50	34	15	33

The mica (illite) and quarts plus feldspars content of clay fraction varied from 29 to 41 and 3 to 61 per cent respectly. The montmorillonite plus vermiculite content of the samples was generally low ranging from 0 to 37 per cent, although 5 of the samples had montmorillonite plus vermiculite content above 25 per cent.

From the content of clay minerals it could be roughly concluded that illite content increased from East to South-West while the montmorillonite plus vermiculite content decreased. The content of quartz plus feldspars showed a trend similar to illite. This tendency in the variation of clay minerals was not found to be consistant as many exceptions were noticed. The variation in clay minerals was not found to be correlated with the soil deposited by different rivers.

LITERATURE CITED

Dogar, M.A. 1962 Cation exchange capacity of various soil separates and identification of clay minerals of some West Pakistan soils. M.Sc. Thesis WPAU, Lyallpur.

Hendricks, S.B., and L. T. Alexander. 1939 Minerals present in soil colloids 1. Description and methods of identification. Soil Sci. 48: 257—272.

Jackson, M.L. 1956 Soil Chemical Analysis Advanced Course. University Wisconsin, College of Agri. Deptt. Soils, Madison:

Kanwar, J.S. 1959 Clay minerals in some normal soils of Punjab. Jour. Ind. Soc. Soil Sci. 7 : 249—254.

McNeal, B.L. 1966 Clay mineral variability in some Punjab soils. Soil Sci. 102: 53—58.

Mehra, O.P., and M.L. Jackson. 1959 Specific surface determination by duo-interlayer and mono-interlayer glycerol sorption for vermiculite and montmorillonite analysis. Soil Sci. Soc. Amer. Proc. 23 : 351—354.

Mortland, M.M., and W.D. Kemper. 1965 Methods of Soil Analysis. (Part i) Published by American Society of Agronomy, Inc. Madison, Wisconsin, U.S.A.