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Study of the Alluvial Soils of Madras State
II. Chemical Properties*

by

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Synopsis: Thirty six surface soil samples from the five major river alluviums of the State were studied in detail for their chemical properties. The results indicated variation in the chemical properties along the course of the river alluviums. The close relationship between the clay content and chemical properties of the alluviums probably indicate the homogeneity of the alluvial material studied.

Introduction: The importance of alluvial soils has been discussed in the previous paper (Premanathan and Durairaj, 1963). Studies of the alluvial soils during soil surveys as in the Godavari, Krishna and Tanjore deltas have been done in the composite Madras State. Although considerable work has been done on these soils in our State, a detailed study on the properties of the major alluviums has not so far been made. The chemical properties of these soils are presented in this paper.

Review of Literature: Studies on the genesis and classification of alluvial soils based on morphological, physical, chemical and mineralogical composition have been carried out by Agarwal *et al* (1951, 1952, 1953, and 1956).

From a soil survey of the Tanjore delta, Harrison and Ayyangar (1914) indicated the low nitrogen status of these soils, the need for phosphorus fertilisation and the sufficiency of potash in these soils.

After studies on the alluvial soils of the Mississippi drainage basin, Holmes and Hearn (1942) concluded that the chemical composition of alluvial soils derived from the various geological areas reflected in general, the differences in their geological material, as well as the differences in the altered composition of the soils as they developed in areas made up of these materials. Low phosphate fixation in the Indo-Gangetic alluvial soils was found by Patel and Viswanath (1946).

Pathak and Mukerji (1950) reported that in the alluvial soils of Kanpur, phosphate fixation was mainly by clay followed by silt and sand and that removal of humus by hydrogen peroxide increased the phosphoric acid and potash-fixing capacity of the soils. Kunhirama Menon (1952) reported a general deficiency of available phosphoric acid and nitrogen and of lime in a few patches on soils of the Tanjore delta.

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In the Stewart's scheme (1959) conducted in Tanjore district the alluvial soils of Cauvery delta was surveyed. Raychaudhuri (1953) found that the Godavari river carried much fertile mud because of the trap rock terrain while the Cauvery silts, were relatively poor. Basu and Tagare (1954) noted that the alluvial soils of North Gujarat were low in pH value and soluble salts, while black alluvial soils of South Gujarat and Khandesh districts were colloidal, clayey, low in salts, fairly high in pH and recorded varying contents of phosphoric acid.

Driskell (1954) studying the chemical characteristics of the lower Mississippi alluvial soils, found that soil constituents were modified by time and environment, the molar ratios and the carbon and nitrogen contents varying with soil series depending upon the sources of materials. Intensive cultivation, according to Ghildyal, Shrikande and Rajendra Prasad (1961), exerted a profound influence on the soil genesis and tended to reduce fertility, as evidenced by studies of the Gangetic alluvium both under cultivation and afforestation.

Materials and Methods: Thirty-six samples (0–9") were collected from the five major river alluviums of the Madras State, namely the Palar, Ponnaiyar, Cauvery, Vaigai and Tambraparni, representing the different stages of the course of the rivers. These samples were analysed for moisture, loss on ignition, silica, iron, alumina, nitrogen (total and available), phosphoric acid (total and available), potash (total and available), lime, magnesia, organic carbon, total soluble salts, electrical conductivity, soil reaction, cation exchange capacity and exchangeable calcium by recognised methods. Silica-sesquioxide ratio and carbon-nitrogen ratio were worked out. Simple correlations were worked out between the clay and the different constituents of the chemical analysis. The results are presented in Tables I and II.

Results and Discussion: (1) *Progressive variation in chemical properties proceeding along the river:* There was some variation along the course of the river. The silica content was found to vary depending on the texture of the soils of the tract through which the river traversed. There was a close relationship between the clay content and silica content ($r = 0.934$) in spite of the river variation. With reference to alumina content, the trend was similar to that of silica content, but the relationship was not very close.

The pH of the alluvial soils varied along the course of the rivers, reflecting the soil types of the tracts traversed by the river. Higher pH was noticed wherever black or brown soil occurred and it decreased where red soils were traversed. The general trend in electrical conductivity was to decrease along the course of the river.

(2) *Nutrient status:* The nitrogen and potash contents were found to decrease to a certain extent along the course of the alluvium. The total and available phosphoric acid and available potash contents were found to vary along the course of the river alluviums within wider limits. The available nitrogen content was found to be fairly uniform for all the alluviums. There was a very

close correlation (r = 0.912) between the total phosphoric acid content and the available phosphoric acid content indicating that the phosphorus was probably present mainly as a single calcium phosphate. The lime content was found either to increase or decrease along the course of the river. The lime-magnesia was between 1 and 2, thereby indicating that the proportion of these elements was within the safe range.

TABLE I

Nutrient Status. (Percentages, moisture-free basis)

S. No.	Nitrogen (N)		Phosphoric acid (P_2O_5)		Potash (K_2O)		Lime (CaO)	Magnesia (MgO)
	Total	Available	Total	Available	Total	Available	Total	Total
1.	0·079	0·014	0·080	0·018	0·958	0·071	1·47	0·79
2.	0·069	0·003	0·060	0·021	0·944	0·041	0·74	0·56
3.	0·072	0·004	0·205	0·101	1·119	0·061	0·69	0·53
4.	0·097	0·012	0·061	0·026	0·792	0·049	1·07	0·88
5.	0·036	0·009	0·077	0·054	0·907	0·056	0·51	0·42
6.	0·033	0·003	0·022	0·004	0·795	0·031	0·51	0·33
7.	0·031	0·013	0·030	0·008	0·565	0·017	0·29	0·28
8.	0·058	0·013	0·044	0·014	0·741	0·015	0·48	0·43
9.	0·023	0·004	0·026	0·003	0·443	0·030	0·57	0·15
10.	0·043	0·007	0·028	0·009	0·433	0·019	0 73	0·10
11.	0·109	0·020	0·183	0·140	0·711	0·069	1·01	0·60
12.	0·068	0·009	0·040	0·033	1·083	0·039	0 97	0·52
13.	0·044	0·009	0·053	0·032	0·717	0·024	0·58	0·25
14.	0·127	0·012	0·121	0·059	1·116	0·080	0·71	0·30
15.	0·069	0·010	0·196	0 019	0·768	0 024	1·53	0·67
16.	0·055	0·010	0·061	0·010	0·982	0·024	0·98	0 59
17.	0·064	0·009	0·218	0·090	0·863	0·043	0·74	0·62
18.	0·084	0·026	0·247	0·131	1·001	0·034	1·11	0·59
19.	0·101	0·012	0·093	0·040	0·802	0·088	2·63	0·47
20.	0·106	0·013	0·072	0·014	1·009	0·021	1·18	1·08
21.	0·132	0·028	0·395	0·138	0·927	0·020	3·14	0·87
22.	0·086	0·017	0·361	0·141	1·039	0·073	0·70	0·59
23.	0·123	0·014	0·186	0·083	1·323	0·068	0·78	0·54
24.	0·133	0·021	0·189	0·129	0·496	0·074	1·20	0·72
25.	0·058	0·010	0 071	0·024	0·652	0·046	0·80	0·80
26	0·100	0·017	0·069	0·020	0·548	0·035	0·82	0·65
27.	0·104	0 007	0·180	0·105	1·175	0·031	2·32	0·55
28.	0·139	0·025	0·040	0 024	0·976	0·023	0·74	0·49
29.	0·097	0·006	0·080	0·031	1·068	0·031	2·97	1·29
30.	0·058	0·011	0·086	0·028	1·093	0·032	1·74	1·47
31.	0·043	0·009	0·093	0·076	0·636	0 090	0·63	0·58
32.	0·054	0·014	0·113	0·070	0·621	0·053	0·72	0·61
33.	0·054	0·013	0·182	0·089	0·762	0·055	0·79	0·74
34.	0·117	0·015	0·050	0·003	0·538	0·024	0·19	0·18
35.	0·149	0 082	0·056	0·034	0·807	0·045	0·38	0·19
36.	0 102	0 018	0·082	0·033	0·902	0·072	1·08	1·21

S. No. 1 to 7—Palar alluvium; 8 to 13—Ponnaiyar alluvium;
14 to 26—Cauvery alluvium; 27 to 33—Vaigai alluvium;
34 to 36—Tambraparni alluvium.

The organic carbon content varied along the course of the alluviums. It decreased along the course, in the case of the Palar, Ponnaiyar and Vaigai river alluviums, whereas, it increased along the course of the Cauvery and the Tambraparni river alluviums. The loss on ignition and organic carbon content were found to be correlated very closely (r = 0.871). Similarly clay content and loss on ignition were found to be correlated closely (r = 0.872).

(3) *Relationship between properties:* Although there were wide variation in many of the chemical properties, it was observed in many of the relationships that high correlations were obtained, when all the river alluviums were considered together. This is strikingly peculiar and probably indicates the uniformity of the alluvial material, especially clay, for the rivers studied. This was substantiated by the close correlations obtained between the clay and the chemical properties in the present study (vide Table II) and the clay and the physical properties studied elsewhere (Premanathan and Durairaj, 1963). This is evident, since the clay forms the most reactive part of the soil influencing the various properties of the soils. The influence of clay content on the chemical properties like loss on ignition, silica, alumina, and cation exchange capacity was pronounced. Comparing the relationships obtained in the present study with those obtained by other workers, it was seen that correlation coefficient in respect of loss on ignition was found to be in general agreement with those of Charlton (1936) and Sen and Deb (1941), but was appreciably higher than that obtained by Russell (1923), Joachim and Kandiah (1947) and Venkataramanan (1962).

TABLE II

Relationship between Chemical Properties.

S. No.	Relationship between X — Y	Correlation Coefficient (r)	Regression equation	Number of pairs of values
1	2	3	4	5
1.	Clay — Loss on ignition	0·872*	Y=1·08X — 20·62	32
2.	Clay — Silica	0·934*	Y=3·84 + 0.279X	35
3.	Clay — Alumina	0·779*	Y=1·97 + 0·176X	35
4.	Clay — Cation exchange capacity	0·874*	Y=4·18 + 0·60X	36
5.	Silica — Alumina	0·901*	Y=0·62X — 0·42	35
6.	Silica — Sesquioxide	0 916*	Y=0·96 + 0·91X	35
7.	Loss on ignition-Total nitrogen	0 696*	Y=0·030 + 0·02X	35
8.	Total nitrogen-Organic carbon	0·893*	Y=8·62X — 0·011	35
9.	Loss on ignition-Organic carbon	0·871*	Y=0·052 + 0·247X	34
10.	Total P_2O_5 — Available P_2O_5	0·912*	Y=0·003 — 0·439X	34
11.	Cation Exchange capacity-Exch. Calcium	0·829*	Y=0743X — 1·74	32

*Significant at one per cent level.

A major portion of the variation in the silica and alumina content was found to be accounted for by the variation in the clay content. The correlation coefficient for the relation between clay and silica was very close (r = 0.934) and that of clay and alumina was not as close as the former (r = 0.738). The finding confirmed the previous work of Durairaj (1961) and Venkataramanan (1962). There was a close correlation (r = 0.901) between silica and alumina content and

between silica and sesquioxide content (r = 0.916). The narrow range of values for the silica sesquioxide ratio also may be taken as an indication of the fair homogeneity of the alluvial material.

There was a close correlation (r = 0.874) between the clay content, and the cation exchange capacity. This was in agreement with the work of Venkataramanan (1962) (r = 0.818). It was found in the present study that the greater part of the exchangeable cation was taken up by exchangeable clacium, the correlation coefficient obtained in this case being r = 0.829. This agreed with the previous work done by Venkataramanan (1962). On clay basis there seemed to be a general trend of increase in the cation exchange capacity as the delta was approached. This may be due to the recombination of silicic acid with 1 : 1 type of clays (Robinson, 1949).

Summary and Conclusions: Thirty-six surface soil samples (0–9") from the five major river alluviums, namely, Palar, Ponnaiyar, Cauvery, Vaigai and Tambraparni alluviums, were studied in detail for their chemical properties. The results indicated variation in the chemical properties along the course of the river alluviums. There was a very close relationship between clay content and chemical properties even when all the river alluviums are put together. This probably indicates the homogeneity of the alluvial material studied. A similar trend was obtained between the clay content and physical properties of these alluvial soils. With reference to the nutrient status, all the alluviums except Ponnaiyar alluvium, were satisfactory and the Ponnaiyar alluvium needed nitrogen and phophorus fertilisation.

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* Original not seen.