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Alkali Soils of the Amaravathy project, their characteristics, diagnosis and reclamation *

by

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Synopsis: A detailed study conducted on the alkali soils of the Amaravathy Ayacut is reported in this paper. The study has revealed that the main factors responsible for the genesis of these alkali soils are the poor drainage, topographically low lying situation and the higher water table. High correlation exists between pH and exchangeable sodium percentage in these soils. Soil pH has been suggested for their diagnosis. Application of gypsum at 2 tons/acre, with green manure at 5,000 lb./acre along with a general improvement of the drainage system have been recommended for the reclamation of the soils.

Introduction: Govinda Iyer *et al* (1961) have reported in their preliminary soil studies of the Amaravathy Reservoir Project ayacut area that saline and/or alkaline soils occur in the low lying areas and response to irrigation in those is of a low order. Therefore, a detailed study of these saline and alkaline areas was undertaken to appraise the genesis and characteristics of the soils and to suggest suitable economic methods to reclaiming such areas.

Review of Literature: De' Sigmond (1924) considers the presence of an impermeable layer essential for the formation of saline soils. Basu and Tagari (1942) from their investigations on the alkaline soils of Deccan canal area concluded that alkali soils are formed as a result of great aridity, topographic situation favouring accumulation of salt washings from elevated areas and due to saline sub-soil water. The evolutionary processes of alkali soils have been designated by De' Sigmond (1927, 1932, 1938) as salinization, alkalinization, desalinization degradation and regradation. Kelley (1951) observes that alkalinization is only an aspect of salinization and applies a common name 'Alkali Soils'. De' Sigmond (1926) has proposed that exchangeable sodium and potassium should be considered as additive in defining alkali soils. Puri (1933) considers exchangeable sodium and potassium together called "degree of alkalinization". Magistad (1945) also has proposed a similar consideration. It has been reported that exchangeable potassium has only a slight or no adverse effect upon the physical properties of soils. The chief chemical characteristic of an alkaline soil is therefore the presence of an abnormally high exchangeable sodium percentage (Richards, 1954).

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In view of the time consuming process of estimating E. S. P. rapid diagnostic techniques based on the relationship between E. S. P. and pH has been proposed by Fireman and Wadleigh (1951). The Salinity Laboratory of the United States (A. H. 1954) has used a ratio called sodium absorption ratio ($Na / \sqrt{\frac{Ca + Mg}{2}}$) to discuss the equilibrium between soluble and exchangeable cations.

Normal agricultural soils containing calcium as the predominant cation in the exchange complex exist in stable aggregates that do no break down on coming into contact with water. Upon aquisition of abnormal quantities of exchangeable sodium these soil aggregates break down and the clay particles disperse in water which quickly fill up all the interstices rendering the soil impervious to air and water. Kelley (1951) observes that this adverse condition of soil contributes substantially to the observed effect on crops.

Materials and methods: The soil samples collected from the low level areas of Amaravathy Project during the detailed soil survey were analysed for texture, salinity status, pH, permeability and exchangeable sodium percentage and value used for preparing this paper.

RESULTS

A. **Genesis:** 1. *Salient findings:* The extracts from the field notes in respect of the representative soil profiles dug in the alkali areas and the laboratory analytical data of the soil samples are presented in table 1.

The above studies revealed that:

(1) All the sites examined occurred in low lying valleys or in the flood plains of drainage rivulets with the ground water table fluctuating within 1 to 5'.

(2) Most of the surface and sub-surface soils in these profiles are light textured with varying amounts of calcium carbonate (kankar) in the sub soils.

(3) The colloidal complex of the soil is abnormally saturated with sodium. The sub-horizons are sticky and impervious resulting in a low rate of a laboratory permeability.

(4) The concentration of water soluble salts is generally within 0·25% with sodium carbonate as the major constituents resulting in a soil pH greater than 8·5.

TABLE I

Results of Field and Laboratory Examination of Soils from Representative Alkali Soil Profiles in the Amaravathy Project area

Name of the village	Soil depth	Soil Texture	Drain-age	Water table	Conc. & Comp. of soluble salts	Lab. permea-bility	Soil pH	Exch. Sod. %	Kankar	Remarks
Elayamuthur S. No. 279/1 Pit (43)	32″	Sandy loam	Poor	30″	<0·2 mostly Na_2Co_3	12 to 77	9 to 10·5	30 to 36	Present in all depths	Low level area–flood plain of Pallikondan odai
Pappankulam S. No. 345/A Pit (76)	30″	Sandy	,,	25″	,,	1 to 32	9·5 to 10	29·5 to 32·6	Do.	Low level area–on the flood plain of Nochi odai
Nilambur West S. No. 367 Pit (57)	36″	Do.	,,	32″	,,	130 to 150	8·7 to 9·6	20 to 26	Abundant below 12″	Low level area subject to flooding
Vedapatti S. No. 107 Pit (71)	24″	Sandy to sandy loam	,,	...	,,	130 to 200	8·7 to 9·0	20 to 23	Do.	Near pecker odai
Jothampatti S. No. 100 Pit (72)	15″	Do.	,,	15″	,,	35 to 68	9·6 to 9·7	28 to 29	Slight	Least elevated part of an elongated basin shaped area
Thungavi S. No. 119 Pit (73)	32″	Do.	,,	32″	,,	123 to 206	8·9 to 9 1	22 to 24	Present from 18″ downwards	Near canal at 23/6 A levelled up area
Karatholuvu S. No. 828 B Pit (50)	36″	Sandy	,,	36″	0·18 to 0·25	44 to 222	8·9 to 9·4	22 to 30	Abundant from 15″	Low lying area with a kankar pan at 15″ where the lab. permeability is 29
Kumara-palayam Pit (58)	28″	Sandy loam	,,	Even at ground level	<0·2	108 to 142	8·6 to 9·3	19·6 to 26·0	Small amount	Low level area with black patches of alkali
Devanallur S. No. 915 Pit (62)	35″	Do.	,,	35″	,,	36 to 79	9·1 to 9·6	24 to 28	Do.	Low level area newly brought under cultivation
Kothanmuthan-pallam S. No. 861 Pit (61)	20″	Sandy	,,	20″	,,	78 to 100	9·5	28	Varying amounts	Low level area by the side of a drainage channel; water stagnation
Chettipalayam Pit (66)	24″	Sandy loam	,,	24″	0·3 to 0·4	5·3 to 118	8·0 to 8·7	14 to 20	From 24″ downwards	A level area turned alkaline after irrigation was started
Periaputhur Pit (65)	23″	Do.	,,	24″	<0·2	Highly Permeable	9·3 to 9·7	26 to 29	From 20″ downwards	A levelled up area

2. *Factors:* During the third year after the introduction of irrigation, Govinda Iyer and Subramanyam (1960) undertook a study of the quality of canal and well waters and concluded that: (1) the canal water was of low sodium and low salinity, (2) the water in the tail ends of the distributories and drainage from fields was alkaline and (3) the well waters were of medium to high salinity with sodium comprising just over 50% of the soluble cations on the average. Subsequent studies on the quality of water showed that the salt level in the well waters was falling off with more and more irrigation. It follows therefore, that before the introduction of irrigation, these well waters which were the only source of irrigation, were much more saline with a greater percentage of sodium salts. Due to low rainfall and an undulating landscape, on irrigation with such saline waters in the ayacut area, the accumulation of soluble salts were favoured in the low lying areas. Depending upon the concentration and composition of soluble salts more or less sodium became adsorbed by the exchange complex. The replaced calcium was precipitated as calcium carbonate on the soil mass. Thus, salinization mainly existed before irrigation was introduced.

After irrigation was introduced the process of desalinization started with full intensity. The soluble salts were leached out of the soil profiles. When the salt content was thus reduced some of the adsorbed sodium ionised and picked up carbon-di-oxide to form sodium carbonate; the soil pH rose, the clay became dispersed and drainage within the profile got reduced. This sodium carbonate also dissolves in the irrigation water when it reaches these areas and is thus alkaline in reaction.

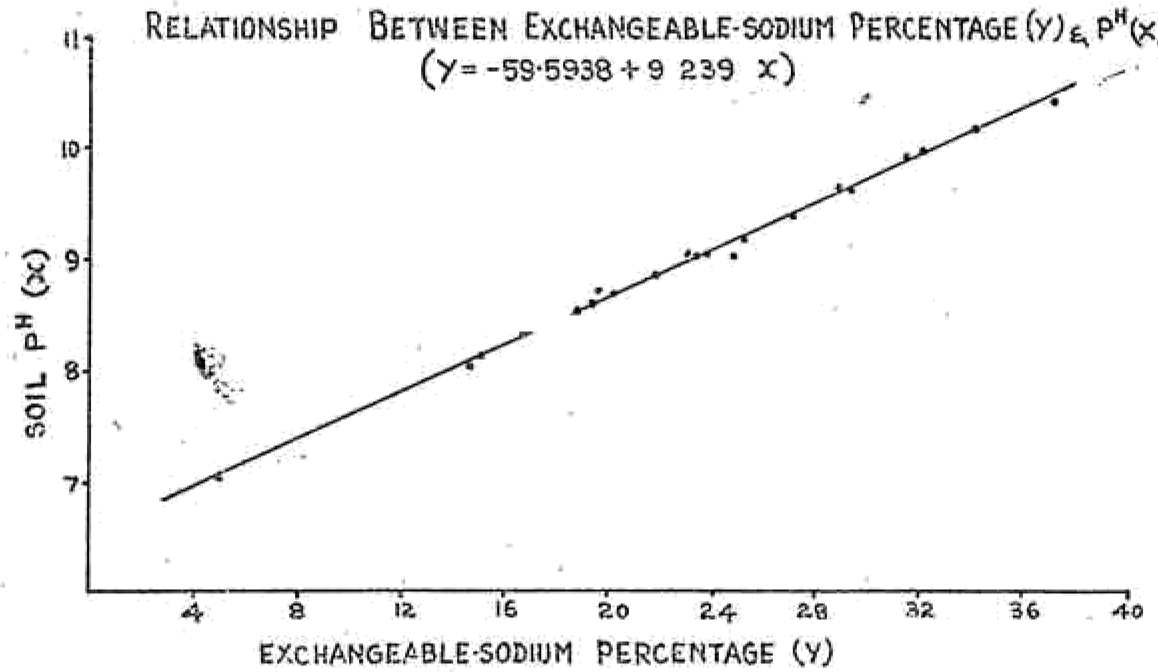
In addition to this, the water table particularly in the valleys has risen up and fluctuates within 1 to 5 thus restricting the internal drainage which favours the accumulation of sodium carbonate within the zone due to evaporation of water rich in sodium carbonate. This further accelerates the process of soil decay described earlier.

Therefore, the main factor responsible for the genesis of these soils is the inadequate drainage, both external and internal, the former due to either a topographically low lying situation or defective drains and the latter due to the occurrence of a high water table during the cultivation season. These soils are characterised by comparatively low content of soluble salts (within 0·25%) throughout the profile due to the extensive seepage that occurs. The abnormal adsorption of sodium by the soil exchange complex under these conditions of the low electrolyte content favours the hydrolysis of adsorbed sodium, high dispersion of clay and the development of high soil pH. Rapid hydrolysis of sodium clay is presumed by Agarwal and Yadev (1954) to be also promoted by the monsoonic climate and higher temperature prevailing in the tropics. Extreme cases of soil deterioration occur along shores of drainage ways where nothing but sand and kankar nodules are seen.

B. **The suitability of rapid diagnostic techniques for the Alkali soils:** The data on E. S. P. and pH of the profile soil samples were utilised to test the suitability or otherwise of the use of soil pH to estimate the E. S. P. The values of soil pH (x) and E. S. P. (y) obtained for the different soil samples were plotted on a graph and the scatter diagram (Fig. 1) thus obtained shows a strong positive correlation between the values, with only 3% of the values falling outside the range, Mean ($9{\cdot}15 \pm 1$). The correlation co-efficient (r) obtained is 0·96. This gives a value of 92% for the co-efficient of determination which very well justifies the use of soil pH for estimating E. S. P. The following regression equation has been obtained for the data.

$$Y = -59{\cdot}5938 + 9{\cdot}239\ x$$

The standard error for the predicted average value of E. S. P. is only 0·7. The soil pH may therefore be used for estimating E. S. P. for the soils of the Amaravathy ayacut area with reasonable precision and coverage.



The alkali soils of the Amaravathy ayacut area show in general an average pH value of 9·1. The estimated E. S. P. for these soils is about 23·5. A pH value of 8·0 or more invariably indicate an E. S. P. value of 15 or more and is in agreement with the results obtained by Agarwal and Yadev (1950) working with saline and alkaline soils of Indian Gangetic alluvium.

C. **Reclamation:** Govinda Iyer *et al* (1961) have concluded after a thorough study of crop growth response in these alkali soils that the crops grow normally upto pH of 8·5 which suggests an E. S. P. value of 19. It follows therefore that crop grown usually in the ayacut area tolerate an E. S. P. value of 19. Hence in any reclamation programme in the ayacut area it is necessary to keep down the soil pH below 8·5 or the E. S. P. value 19. Thorne and Peterson (1954) have arrived at a simple formula for estimating gypsum requirement (G. R.) in tons per acre foot of soil namely G. R. = 1·7. Na. x. where x represents the number of milliequivalents of sodium to be replaced by calcium per 100 gms of soil. So, for a soil having a pH of 9 and so having an E. S. P. value of about 23 the gypsum requirement as per the formula is 6·8 tons per acre foot of soil.

The reclamation of alkaline soils can also be effected by the use of green manure crops, preferably grown *in situ* and ploughed in, which produce carbonic acid and other organic acids during decomposition. Sanyasi Raju and Govinda Iyer (1953) found that in sandy alkaline soils green manure at the rate of 5,000 to 10,000 lb. per acre as a soil amendment proved more effective than gypsum at 5 tons per acre in promoting rice yield. Perhaps the complete replacement of exchangeable sodium by calcium brought about by gypsum makes the soil extremely porous and non retentive of water so essential for paddy. It follows, therefore, that Amaravathy ayacut area soils also being of a light texture and paddy being mostly cultivated in the affected areas, the dose of gypsum as obtained by the formula may prove excessive and uneconomical. It was also found during the survey tours that ryots were effectively reclaiming the affected soils by the application of green manure alone at a rate of 7,500 lb. per acre, followed by efficient leaching. However, this process was found to be slow. Therefore, from the practical point of view it is suggested that a quantity of gypsum not exceeding half the calculated amount together with 5,000 lb. of green manure per acre may be used with advantage for quick as well as efficient method of reclaiming these affected areas.

Further, the specific nature which accounts for the non response to irrigation in these alkali soils is the impeded drainage within the soil profile and the high water table. Water logging occurs during critical stages of the growth of crops. Therefore, a general improvement in the existing drainage system and its maintenance in good repair are of paramount importance for the permanence of reclamation in these affected areas.

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